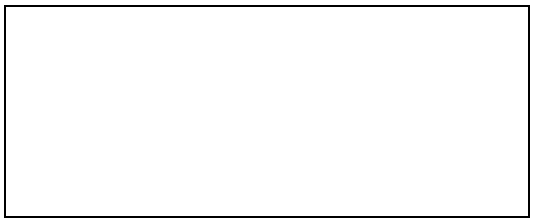
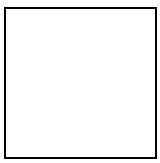
Annotated Bibliography of BASMAA Studies

Revised September 1998

Sponsored by the
Bay Area Stormwater Management Agencies Association



Prepared by the
San Francisco Estuary Institute



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BASMAA

Bay Area Stormwater Management Agencies Association

INFORMATION SHEET

What is BASMAA?

The Bay Area Stormwater Management Agencies Association (BASMAA), is a consortium of the following seven San Francisco Bay Area municipal storm water programs, representing 89 agencies, including 78 cities and 5 counties:

Alameda Countywide Clean Water Program,

Contra Costa Clean Water Program,

Fairfield-Suisun Urban Runoff Management Program,

Marin County Stormwater Pollution Prevention Program,

San Mateo Countywide Stormwater Pollution Prevention Program,

Santa Clara Valley Nonpoint Source Pollution Control Program, and

Vallejo Sanitation and Flood Control District.

In addition to the members listed above, the following agencies participate in some BASMAA activities:

California Department of Transportation (Caltrans), and

City and County of San Francisco.

Why a BASMAA?

BASMAA was started by local governments to facilitate information sharing and cooperation, and to develop products and programs that would be more cost-effective done regionally than could be accomplished locally. In addition, BASMAA provides a forum for representing and advocating the common interests of member programs at the regional and state level. BASMAA is focused on regional challenges and opportunities to improving the quality of storm water runoff to the San Francisco Bay and Delta.

How is BASMAA organized?

BASMAA's organization chart consists of a Board representing the seven municipal programs and four committees that report to the Board.

Monitoring Committee	New Development Committee
Public Information/Participation Committee	Operational Permits Committee

The Executive Director is staff to BASMAA. He reports to the Board and acts as liaison between the BASMAA committees and the Board, between the committees themselves, and between BASMAA and other organizations and agencies.

How does BASMAA work?

The seven member programs of BASMAA have all agreed to the terms of a memorandum of understanding (MOU) that sets policy on member's roles and responsibilities, and describes the purpose and basic operations (e.g., voting, dues) of the organization. Each year BASMAA collects dues from its members for a "baseline" program. The baseline program provides for staff (Executive Director) and finances baseline projects (i.e., projects endorsed by all member storm water programs). In addition, the BASMAA MOU provides a means for two or more of the member programs, or other organizations, to agree to contribute additional funds to do "tasks of regional benefit." This option allows regional or subregional projects to go forward absent a unanimous endorsement by the seven member programs.

Typically, the BASMAA Board and four committees meet monthly on a regular schedule to share information, discuss issues, and manage projects and programs. BASMAA does some projects and programs in-house using BASMAA staff and volunteer time from staff of the member storm water programs. In other cases, BASMAA hires consultants to carry out new projects and programs.

BASMAA works closely with the San Francisco Bay Regional Water Quality Control Board, and with sister regional organizations such as BADA (Bay Area Dischargers Association), a consortium of large wastewater treatment plants; the BAPPG (Bay Area Pollution Prevention Group), a group of representatives from large and small wastewater treatment plants and from some storm water agencies; and SFEI (San Francisco Estuary Institute). BASMAA also participates at the state level in the California Storm Water Quality Task Force.

BASMAA SPECIAL STUDIES STATUS LIST

Project No.	Description	Status*	Program Entities Conducting Studies
A: Impacts on Creeks and Bay			
A.1	Ecosystem Assessment	1	UC Berkeley
A.2	Duration/Persistence Analysis	2	SCVNPSPCP
A.3	Fate and Transport	2	ACCWP
A.4	Indigenous Organisms as Bioindicators	2	LBL
A.5	Develop WQOs	2	ACCWP
A.6	Geochemical Analysis	2	ACCWP
A.7	Analysis of Monitoring Data	2	BASMAA Monitoring Committee
A.8	Pollutant Contribution from Open Space	1	CCCWP
A.9	Environmental Renewal	2	CCCWP
A.10.1	Diazinon in Sediments	2	ACCWP
A.10.2	Characterization and Sources of Diazinon	2	ACCWP
B: QA/QC			
B.1	Automated Sampler Bias	2	CCCWP
B.2	Standardized Analysis Parameters	2	BASMAA Monitoring Committee
B.3	Specialized Analysis Methods	2	SCVNPSPCP (PAH, Se, Hg)
B.4	Clean vs. Ultra Clean Methods	2	SCVNPSPCP
B.5	Field Filtration Study	2	ACCWP
	Usefulness of Immunoassays	0	ACCWP

C: Source Identification/Control			
C.1.1	Transport Pathways	2	ACCWP
C.1.2	Source Identification and Control	2	SCVNPSPCP
C.1.3	Aerial Deposition	2	BASMAA
C.2.1	Road Surfaces/Parking Lots	2	SCVNPSPCP
C.2.2	Parking Lots	2	SMCSTOPPP
C.2.3	Streets/Catch Basins	2	CCCWP
C.3	Roofing Materials	2	ACCWP
C.4	Brake Pad Composition	2	SCVNPSPCP
C.5	Focused Source ID Field Studies/Methods	2	ACCWP
C.6	TIE Testing	2	ACCWP
C.7	ID Products w/Problem Pollutants	2	SCVNPSPCP
C.8	Erosion Sources	2	SCVNPSPCP
C.9	Rainfall Toxicity	0	
C.10	HHW VSQG	1	Sunnyvale
C.11	Product Fate/Life Cycle Assessment	0	
C.12	Abandoned Mine Runoff—Marsh Creek	2	CCCWP
C.13	Watershed Source Identification	2	ACCWP
C.14	Stream Sediment Sampling Methods/Characterization	1	SCVNPSPCP
C.15	Microbiological Indicators Testing	2	SMCSTOPPP
C.16	Copper Content of Street Sweeping Material	0	SMCSTOPPP

C.17	Cypress Project Water Quality Monitoring	1	Caltrans 4
C.18	Septic Systems	1	CCCWP
D: BMP Evaluation			
D.1	Development of Long-term Plan for Evaluation of BMPs	0	
D.2	Catch Basin/Drop Inlet Cleaning	2	ACCWP
D.3.1	Street Sweeping	2	ACCWP
D.3.2	Street Sweeping	2	SCVNPSPCP
D.5	Quantification of BMP Effectiveness	0	
D.6.1	Metals in Water Supply — Copper Sulfate Control	2	SCVWD
D.6.2	Metals in Water Supply — Corrosion	2	SCVWD
D.7	Alternative Roadside Vegetation	2	CCCWP
D.8	Filtration/Settling BMPs	2	SMCSTOPPP
D.9	Mobile Cleaning BMPs	2	BASMAA Monitoring Committee
D.10	Saw Cut Slurry BMPs		
D.11.1	Monitoring GuidanceÑPost-construction BMPs	2	ACCWP
D.11.2	Monitoring Guidance—Treatment Controls	2	BASMAA Mon. & New Development Commission
E: Treatment Control Measures			
E.1.1	Detention Basin	2	ACCWP
E.1.2	Detention Basin	2	SCVNPSPCP
E.2	Wetlands	1	ACCWP
E.3.1	Vegetated Channels	1	ACCWP
E.3.2	Vegetated Swales	1	ACCWP

E.4	Sand Filters	0	
E.5	Porous Pavement/Sand Filter	2	Dublin
E.6	Infiltration	0	
E.7	Storm Drain Inlet Design	0	
E.8	BMP Selection Criteria	0	
E.9	POTW Pilot Diversions	1	RWQCP—Palo Alto
E.10	Post-construction/New Development BMPs	1	CCCWP
		0	ACCWP
E.11.1	Interceptors	1	SMCSTOPPP
E.11.2	Interceptors	1	CCCWP
E.12	Modeling	2	ACCWP
F: Watershed Management			
F.1.1	Protocol Application—San Leandro Creek	2	ACCWP
F.1.2	Coordinated Volunteer Monitoring	2	SWRCB-SFEI
F.1.3	Macroinvertebrate Protocol Development	2	CCRS
F.1.4	Water Quality Parameters—Data Quality	?	CCRS
F.1.5	Water Quality Monitoring—Wildcat Creek	1	Urban Creeks Council
F.2.1	Stream Restoration—Wildcat Creek	1	
F.2.2	Walnut Creek (Design and Implementation)	?	
F.3	Technical Information on Riparian Habitat San Francisquito Creek	1	CCRS
F.4	Institutional Approach	2	CONCUR/PERC
F.5.1	Pilot Watershed Assessment	2	SMCSTOPPP

F.5.2	Impervious Cover Assessment	2	SMCSTOPPP
F.6	Marsh Restoration	0	
F.7	Adopt-a-Creek Program	1	Citizens Efforts
F.8	Hydrology vs. Water Quality	2	ACCWP
F.9	GIS	1	CCCWP

*Status Key 0 - No Work Done 1 - Study Ongoing 2 - Study Done

A. IMPACTS ON CREEKS AND BAY

Title: **1994 Annual Report: Volume III, Element Reports — Part 3 Annual Monitoring**

Description: Duration/Persistence Analysis

Project Number: A.2

Sponsoring Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: storm water flows, water quality objective exceedances, Guadalupe River (Station S3)

Objectives:
1) evaluate duration of water quality objective exceedances during storm events and after return to base flow
2) evaluate adequacy of using flow-weighted samples

SCVNSPCP collected grab samples on the Guadalupe River (Station S3) in FY 1991–92 and 1992–93 to evaluate the duration of Water Quality Objective (WQO) exceedances in waterways during storm events and after return to base flow. A second objective evaluated adequacy of using flow-weighted samples as a guide to evaluating compliance with applicable WQOs.

Results indicated that duration of exceedance of WQOs was not equivalent to duration of the storm runoff event. Exceedance for total metals occurred only during times when storm water flow was highest. Dissolved metal concentrations did not vary significantly throughout the storm event. Flow weighted sampling was demonstrated to be a reliable method to evaluate compliance of storm water discharges in waterways with established WQOs. Analysis for total metals showed that copper, lead and zinc concentrations were lower in post-storm versus during-storm samples. Post-storm samples did not exceed WQOs. Results indicated elevated concentrations of total metals do not persist after storms and dissolved metal concentrations are generally very low during and after storm events.

No recommendations were stated in this report.

Title: **Evaluation of Metal Sources and Fate in Streams**
In: 1991–92 Annual Monitoring Report: Section 5.3

Description: Fate and Transport

Project Number: A.3

Sponsoring Program or Organization Conducting Study: Alameda Countywide Urban Runoff Clean Water Program

Contact: Jim Scanlin (510) 670–6548

Key Words: Cd, Cr, Cu, Pb, Ni, suspended sediment, fate and transport, storm water discharge, San Francisco Bay

Objectives:
1) estimate metal enrichment of suspended stream sediments
2) compare with Bay sediment concentrations and the particulate fraction of the receiving water

As part of ACURCWP ongoing monitoring program, analysis was done on collected data to determine how metal concentrations in suspended stream sediments compare to those of streambed sediments.

Results indicate if metals concentrations on suspended particulates are due mainly to re-suspension of previously deposited sediments or from input of additional metals from surface runoff. Existing water quality data were used to calculate metals present on suspended solids collected from Alameda County streams during storm events and adjusted to compare with benthic stream sediment for Cr, Cd, Cu, Pb, Ni, and Zn. Similar calculations were used for South SF Bay surface water.

Results indicated the suspended sediments were enriched in Cd, Cu, Pb, and Zn compared to benthic sediments, while Ni and Cr appeared not enriched. This suggests that surface runoff, rather than re-suspension of benthic stream sediments, supplied these suspended sediments.

Partition coefficients were calculated for metals in streams and in South SF Bay to determine the fate of metals discharged into the Bay. Even though there is not much data on the Bay concentrations, some general conclusions can be drawn. Cd and Cr appeared to remain attached to particles when discharged into the Bay. A portion of Cu, Ni, and Zn appear to be released when discharged into the Bay. Stream particles entering the Bay appeared to remove dissolved Pb from the water column in the Bay.

Title: **Spatial and Temporal Variations in Toxicity in an Urban Runoff Treatment Marsh**
In: Environmental Toxicology and Chemistry, Vol. 14, No. 3, 1995

Description: Indigenous organisms as bioindicators

Project Number: A.4

Sponsoring Program or Organization Conducting Study: Lawrence Berkeley Laboratory

Contact: Susan Anderson, (510) 486–4654, Revital Katznelson (510) 874–3048

Key Words: storm water toxicity, stream-wetland gradients, marsh treatment

Objective: Quantify toxicity of urban runoff in creek and marsh

Ceriodaphnia dubia toxicity tests were used to quantify the toxicity of urban runoff at Crandall Creek and the downstream DUST (Demonstration Urban Stormwater Treatment) Marsh near Fremont, CA, in the winters of 1991–92 and 1992–93. Acute toxicity, expressed as median time to lethality (LT50) for *C. dubia* was used to compare intensities of toxicity in this system.

During and shortly after storm events gradients in LT50 and electrical conductivity were observed that showed a high inverse correlation between the two parameters, implicating substances in storm water, not salinity as responsible agents of toxicity. Toxicity diminished with time after the storm. Performance of the DUST Marsh as a treatment facility was evaluated for detention, dilution and toxicity removal.

Results showed:

1) that toxic storm water generated by small to medium sized storms (5 to 25 mm precipitation) was contained in the marsh.
2) Toxicity was greatly reduced upon dilution of storm water runoff with pre existing marsh water.
3) Mixing of the water column in the marsh increased the rate of toxicity decline.
4) Toxicity reduction, above and beyond that attributable to dilution, was evident in the marsh.

This study demonstrated the potential use of toxicity assessments as an integral component of marsh design and management.

Title: **Geochemical Modeling**
In: 1992–93 ACURCWP Annual Monitoring Report, Appendix B

Description: Geochemical Analysis

Project Number: A.6

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Jim Scanlin, (510) 670–6548

Key Words: Metal speciation, modeling chemical behavior of heavy metals, bioavailability, toxicity

Objective: Prediction of fate and speciation of copper from total Cu concentrations

As part of ACURCWP's Storm Water Management Plan for 1992–93 monitoring and analysis, Woodward Clyde prepared a geochemical equilibrium model (MINTEQA2 Version 3.d) and assessed it for potential to predict chemical behavior of heavy metals in a stream discharging into San Francisco Bay. A station on Alameda Creek was selected as a representative site, and Cu was the test metal. The model simulated Cu percent in solution as a function of TSS and pH. Complexation of Cu with natural dissolved organic matter was also computed.

Results showed the model simulated the distribution between dissolved and adsorbed Cu species. It can predict the chemical fate and speciation of Cu from total Cu concentrations measured during storm events. This may help to more precisely evaluate the impact of Cu in the receiving water body as bioavailability and toxicity are linked to speciation. It's likely this model can simulate the chemical behavior of other heavy metals.

The model showed varying degrees of sensitivity to uncertainties in different input parameters. From most to least sensitive these parameters are: pH, TSS, amorphous Fe content of TSS, carbonate concentration, dissolved organic matter, and salinity.

This study recommends analysis of amorphous Fe content and carbonate concentrations be added to standard analysis list for storm water samples. Complete analysis of the samples should be done regularly, including dissolved heavy metals to enable initial calibration of the model.

Title:	**Open Space Special Study.** In Contra Cost Clean Water Program, FY 1995–96 Monitoring Report
Description:	Open space pollutant water quality assessment
Project Number:	A.8
Program or Organization Conducting Study:	Contra Costa Clean Water Program
Contact:	Tom Dalziel (510) 313–2392
Key Words:	open space, storm water runoff, water quality
Objective:	To compare metal concentrations in storm water runoff from open undeveloped areas with runoff from urban, developed areas

The study was conducted in conjunction with the Program's wet-weather monitoring program. The purpose of the study was to compare metal concentrations in storm water runoff from open, undeveloped areas with runoff from urban, developed areas. The study was conducted to address questions raised from the Program's 1994–95 wet weather monitoring results that indicated some pollutants may come from open space areas rather than urban areas. Contra Costa County Flood Control District staff collaborated with Woodward-Clyde Consultants to complete the study. Preliminary findings indicated sediments from open, undeveloped areas contribute metals to urban runoff. It was also found, however, that urban runoff also contained a significant amount of metals.

The report included several recommendations for additional work during the 1996–97 wet-weather season which were not implemented following a request by the San Francisco Bay Regional Water Quality Control Board's request to cease our fixed station, wet-weather monitoring.

Title: **Contra Costa Clean Water Program, FY 1995–96 Annual Report, Section 7: Equal Discharge Increment (EDI) Method Results**

Description: Environmental Renewal. Comparison of two types of toxicity tests; comparison of sampling methods; automatic sampler versus depth-integrated samples.

Project Number: A.9

Program or Organization Conducting Study: Contra Costa Clean Water Program

Contact: Mal Weston (510) 313–2292, Revital Katznelson (510) 874–3048

Key Words: Toxicity tests, "static" vs. "environmental renewal", sampling methods, depth-integrated, equal discharge increments, fixed point

Objectives: 1) Evaluate toxicity differences based on exposure

2) Evaluate differences in sample collection methods

This study measured the difference between single-point sampling and equal discharge increment (EDI) sampling. It was conducted with the 1995–96 wet weather sampling effort. Study findings showed total and dissolved metal concentrations were lower in samples collected using the EDI method than samples collected using the single-point method. This concentration difference, however, was not significant. Contra Costa County Flood Control and Water Conservation District staff recommended the single-point sampling method was adequate to measure long-term water quality trends. The Program does not intend to transfer its sampling procedures to the EDI method.

Title: **Characterization of the Presence and Sources of Diazinon in the Castro Valley Creek Watershed**

Description: Source identification

Project Number: A.10.2

Sponsoring Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Jim Scanlin (510) 670–6548

Key Words: diazinon

Objectives:
1) characterize spatial and temporal variations in diazinon concentrations in the Castro Valley Creek watershed
2) determine if "proper" use could account for these concentrations

Diazinon, an organophosphate insecticide, has been detected in creeks throughout the Bay Area. Previous toxicity studies showed that storm runoff in Castro Valley Creek was frequently toxic to the aquatic test organism *Ceriodaphnia dubia,* and that diazinon was the most likely cause of this toxicity. Since its watershed is fairly representative of urban land use patterns in the East Bay and the stream is also part of long-term stream monitoring studies, Castro Valley Creek was selected as the site for a more detailed study of diazinon in surface runoff.

The main purpose of this study was to characterize the temporal and spatial patterns of the occurrence of diazinon in the Castro Valley Creek watershed. Runoff at the discharge point for the entire watershed was sampled during multiple storm events to record both seasonal and within-event variations in diazinon concentration. Analysis of these data suggested how seasonal and hydrologic factors may affect diazinon levels, and provided the basis for estimates of concentrations in unsampled runoff and of the total mass of diazinon discharged during the 1995–96 water year. Repeated sampling during and after storm events showed how long diazinon concentrations remained elevated after storms. Since a pollutant's toxicity to aquatic organisms depends on both the concentration and the duration of exposure, the persistence of diazinon in creeks is an important consideration in assessing the ecological impact of diazinon.

Sampling at multiple locations was used to evaluate the spatial distribution of diazinon within the watershed. Results from five major subcatchments indicated that sources are not restricted to particular areas, and samples from street gutters showed that at a smaller scale individual diazinon sources may be very localized. A few street gutter samples contained very high concentrations of diazinon. Data from street gutter samples were used to form a rough estimate of the number of sources in the watershed. Three selected residences were given experimental applications of diazinon to see if subsequent runoff could contain high concentrations of diazinon. Although limited in scope, the test results suggest that residential users applying diazinon in accordance with label directions may contribute significantly to the diazinon in runoff in Castro Valley Creek.

B. QUALITY ASSURANCE AND CONTROL

Title: **Monitoring Protocol Standardization Project**

Description: Standardized analysis parameters: field and laboratory QA/QC and methodology

Project Number: B.2

Program or Organization Conducting Study: Bay Area Stormwater Management Agencies Association

Contact: Geoff Brosseau, (510) 622–2326

Key Words: standardized analysis parameters, data quality objectives, sampling objectives

Objectives: 1) Recommend performance standards

2) recommend changes to existing protocols

The San Francisco Estuary Institute (SFEI) and Woodward Clyde Consultants collaborated to prepare for the BASMAA Monitoring Committee this report to develop regionally standardized collection and analysis protocols for storm water monitoring that meet NPDES permit requirements.

The existing programs provide a general characterization of storm water chemical composition, but current protocols are unable to account for sporadic events. As management goals and questions become more specific, more rigorous and focused measurements and sampling programs can be designed.

A first step is to set lab performance standards. QA/QC procedures must meet the objectives for water quality, even though techniques and procedures may not be completely identical among the three county monitoring programs. New ways of organizing and managing data are necessary to find the pertinent highlights in large data sets.

SFEI proposes a flexible and adjustable information management system and protocols for entering data from the storm water monitoring programs.

The following specific recommendations are made to create sensible standardization in the storm water monitoring procedures:

1) Field blanks should be collected. Pre-deployment QA/QC is advised. Develop a field blank collection method using auto samplers.
2) The lab minimum performance level should be one fifth of WQO. PQL for labs should be determined.
3) Set frequency goals for analysis of field and lab duplicates, spikes and reference materials analysis. Determine a reasonable frequency for QA/QC.
4) Standardize QA nomenclature. Adopt the definitions listed in this report.
5) Establish a baseline parameter list for all. Watershed specific parameters could be added later. Analyze existing data to determine data needs.
6) Collect all data necessary to perform data analysis and reporting. Agree on what hydrologic data should be reported.
7) Detect 40% change in pollutant concentrations. Conduct power analysis using existing data.
8) Use EPA guidance and clean equipment & techniques to measure dissolved metals. Determine if field filtration is necessary.
9) For toxicity protocols, calculate % survival, LT50, and reproductive success per day and per female.
10) Standardize data formats whenever possible.

Title: **QA/QC Control Plan and Chemical Analytical Methods**
In: SCVNSPCP 1991 Amended Monitoring Plan Sec. 2.0

Description: Specialized analysis methods

Project Number: B.3

Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: suspended solids grain size, PAH's, diazinon, low detection analysis methods

Objectives: Recommend a QA/QC plan to quantify data more accurately and to provide a mechanism for control and evaluation of procedures.

Woodward Clyde prepared this portion of the Amended Monitoring Plan requested by SFRWQCB in 1991 for the NPDES permit. Since measurement of chemical constituents at the trace level is often difficult, a strict QA/QC plan will be implemented in the monitoring program to quantify data accurately and to provide a mechanism for control and evaluation of procedures.

Established SOPs (standard operating procedures) will be followed by field personnel and laboratory personnel. Blind equipment blanks and sample duplicates will be used to assess contamination potential. Duplicate field samples will be employed. Sample custody and transfer procedures will be based on EPA recommended procedures. Laboratory analysis methods must meet precision and accuracy objectives by use of duplicates and blind standard reference samples analysis. Contamination will be assessed by analysis of lab blanks and equipment blanks. The completeness of analysis goal is 95%. Detection limits will be reported in the final report summary. Water quality constituents include the metals As, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Zn; organics like oil and PAHs; hardness; TSS and pH. A more sensitive method for Hg (10 times lower) will be used. PAH analysis will use the "PAH GC-MS" method which is superior to EPA method 610 as it detects more PAH compounds at lower levels and minimizes interference. Reporting of these QA/QC data will be part of the Annual Report.

Title: **Evaluation of Sampling and Analysis Program Performance**
In: SCVNSPCP Annual Report Vol. III, Elements Reports—Part 3 Annual Monitoring Sec. 4.1 1993

Description: Clean versus ultra clean methods

Project Number: B.4

Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: Clean and ultra clean methods, sampling analysis metals contamination

Objective: Determine if sampling analysis methods are adequate to measure metals concentrations in storm water runoff

As part of continuing SCVNSPCP monitoring program, quality assurance data were collected to determine if sampling analysis methods are adequate to measure metals concentrations in storm water runoff. Were levels below Water Quality Objectives (WQOs) quantified in storm water samples, especially those that protect freshwater aquatic life?

Results showed:

1) Lab and field procedures are adequate to compare storm water quality with acute water quality objectives;
2) Lab and field procedures were not adequate to compare all samples to chronic objectives for all metals. Specifically most of the total and dissolved Hg, most of the total and dissolved Cd, and significant parts of the total and dissolved Pb samples could not be compared.
3) Lab and field procedures are adequate for determining long term trends for total Cu, Pb and Zn.
4) Lab and field procedures are not optimal to determine long term trends for other total metals (As, Cd, Cr, Hg, Ni, Se, Ag) and for all dissolved metals.
5) Se concentrations were successfully quantified using modified Se analysis for low concentrations.
6) Lab and field procedures were modified to enable quantification of Hg concentrations in grab samples from streams during storms. Results indicated storm water runoff concentrations generally correspond to historical sediment Hg concentrations.

Title: **Field Filtration vs. Laboratory Filtration Pilot Study**

Description: Pilot study comparing results of field filtration to those of laboratory filtration of storm water composite samples

Study Number: B.5

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Terry Cooke (510) 874–1736

Key Words: sampling methods, field filtration, laboratory filtration, partition coefficients

Objective: determine comparability of field filtration to laboratory filtration

Storm water monitoring methods for dissolved metals typically involve collection of a large volume of water into a composite sample container and transfer of the unpreserved sample to the laboratory where a subsample is filtered. However, EPA's preferred method for sampling and measurement of dissolved metals is to filter the sample in the field. Prior to this study, field filtration had not been attempted on storm water composite samples in the Bay Area. In order to determine if field filtration is feasible and necessary to accurately measure dissolved metals concentrations in storm water the Alameda Countywide Clean Water Program (ACCWP) conducted a field filtration pilot study in FY 1995–1996. Woodward-Clyde prepared this report comparing the results of field filtration to those of laboratory filtration for the ACCWP.

Eight matched pairs of filtered and unfiltered grab samples were taken from Castro Valley Creek during a storm event. The unfiltered samples were analyzed for total suspended solids (TSS); hardness; and total and dissolved copper, lead, and zinc, while the filtered samples were analyzed for dissolved copper, lead, and zinc only.

The field filtered results were compared to the laboratory filtered results in four ways: 1. calculation of relative percent differences (RPD) between each matched pair of dissolved metals concentrations; 2. comparison of calculated partition coefficients and relationships between percentage dissolved metal verses TSS and hardness; and 3. comparison of partition coefficients calculated from field filtered grab samples with those calculated using the laboratory filtered flow composite sample; and 4. comparison of dissolved water quality objectives with field and laboratory filtered samples.

1) For copper and zinc the average RPD were 15% and 13% indicating good overall agreement with field filtered dissolved concentrations slightly higher. Most of the laboratory filtered lead samples (75%) were non-detect while lead in the field filtered samples was always detected. Most of the RPDs between individual matched samples were greater than 25% which indicates poor agreement between the individual laboratory and field filtered samples.
2) The partition coefficients and relationships between % dissolved metals, TSS, and hardness calculated using the field filtered samples were more reliable and more consistent with theoretical results (less variable) than the laboratory filtered samples.
3) Field filtered grab sample partition coefficients were also compared to the single flow-weighted composite (EMC) sample (laboratory filtered). Data for lead were similar while the partition coefficients estimated for copper and zinc were higher than their EMC partition coefficients by nearly an order of magnitude.
4) Comparison with dissolved metals water quality objectives were similar for field and laboratory filtered samples (all less than objectives).

In general, the results indicated overall agreement between the two methods. However, field filtration provided less variable results on an individual sample basis. Field filtration is recommended for investigations where accurate dissolved metals concentrations are needed to determine modeling parameters for fate and transport evaluations (partition coefficients). In addition, where practical, field

filtration is preferred method for dissolved EMC measurements because samples can be preserved in the field rather than waiting until after storage and transport to the laboratory.

C. SOURCE IDENTIFICATION AND CONTROL

Title: **1) Distinguishing Natural and Anthropogenic Origins of Nonpoint Source Pollution**
2) Atmospheric Deposition
In: ACURCWP Annual Monitoring Report

Description: Transport pathways

Project Number: C.1.1

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Jim Scanlin (510) 670–6548

Key Words: transport pathways, control points, atmospheric deposition

Objective: Review literature to determine which pollutants are mainly anthropogenic in source.

As part of ongoing monitoring program conducted by Woodward Clyde, source identification studies included a literature review of natural and anthropogenic sources of nonpoint source pollution that is compared to Alameda County Water Quality (WQ) data to determine which pollutants are mainly anthropogenic in source. Comparisons with national data showed for most constituents Bay Area samples were in the 20% of data collected. These studies suggested that Pb and Zn are primary metals contributed by urban activities, Cu to a lesser degree, and Ni and Cr are primarily due to erosion. The enrichment factor for a background station on Strawberry Creek was calculated from the Shacklette & Boerngen study (1984) and these concentrations were applied to other sites in Alameda Co.

The results were consistent with those above. Pb and Zn were significantly enriched above soil concentrations, Cu less so and Ni and Cr even less. Cd found in storm water runoff may be primarily a result of association with Zn.

A literature review of studies of atmospheric deposition (both wet and dry) as a source of nonpoint pollution was also done. But only precipitation quality data from these studies are compared to storm water data from Alameda Co. Results indicate air deposition is a major source of metals to storm water. And climatically dry deposition is probably more important than wet deposition. Cr, Ni, Cu, and Pb rainfall concentrations are about equal to background levels. Zn concentrations in rainfall are about equal to concentrations measured in streams.

Title: **Source Identification and Control Report 1992, SCVNSPCP**

Description: Best management practices and source control measures

Project Number: C.1.2

Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: pollutant transport, control points, atmospheric deposition

Objective: Develop a work plan for implementation of a source control program

This report was prepared by Woodward Clyde for SCVNSPCP to partially satisfy NPDES requirements to implement a source control program that includes Best Management Practices (BMPs) in place and additional Source Control Measures (SCMs) being implemented over four years (1991 to 1995).

The work plan would:

1) identify major sources of pollutant metals in urban runoff and develop control measures.
2) develop a Cu control strategy SC Valley wide of major sources as a pilot effort.
3) assist the City of Santa Clara to implement remedial action to control heavy metal sources from an industrial catchment as an extendible pilot program. This last work item involved inspector training, prioritizing facilities, inspection and follow-up, and specific BMPs design.

The pilot conducted at 16 facilities led to refinement recommendations to improve the program, including more extensive training, clear legal authority, and better advance communication.

Source identification consisted of five steps:

1) select target metals;
2) select source classes (e.g. transportation, spills and dumping, subset leaks);
3) screen and prioritize sources by pollution potential;
4) develop source control measures;
5) develop a Cu control program with implementation schedule.

Results of the five steps:

1) Cu and Hg were determined the critical metals.
2) The major sources classes are atmospheric emissions, automotive, industrial, residential and water supply.
3) the highest priority of sources are #1 greater than 10% of mean annual loads of pollutants #2 one to 10% and #3 less than one %.
4) Source control measures identified were A) air pollution—reduce miles traveled, use cleaner fuels, lower emission standards for diesel, increase public information activities. B) automotive—reduce Cu in brake pads, reduce heavy metals in tires, conduct parking lot BMP pilot, coordinate with Caltrans. C) industrial—prioritize inspections, coordinate monitoring, develop specific SCM guidance, coordinate with county on Hg sediments control, local certification program for exemptions, step up award program, set up incentive program. D) residential—reduce improper paint disposal. E) water supply—monitor control of heavy metal sources.
5) A Cu control program. Reduce Cu emission from mobile sources by reducing single occupant vehicle use, modify fleet fuel mixes, collaborate to lower diesel emission standards, reduce Cu in brake pads (must be change at national level) and reduce Cu in water supply by monitoring progress of corrosion and characterization studies.

Title: **Scoping Study of Air Deposition Monitoring Information Relevant to Water Quality of San Francisco Bay**

Description: Aerial deposition

Project Number: C.1.3

Program of Organization Conducting Study: Bay Area Stormwater Management Agencies Association

Contact: Geoff Brosseau, BASMAA (510) 622–2326

Key Words: deposition, water quality, air quality

Objectives: 1) review air monitoring activities conducted by BAAQMD, USGS, etc.
2) make recommendations for efforts between water and air quality agencies.

Air deposition has been shown to be an important source of pollutants to surface waters around the country, specifically in Tampa Bay, the Great Lakes, and Chesapeake Bay. As a result, water quality agencies have become increasingly concerned that the Bay Area may have the same problem. Preliminary calculations done ten years ago indicated that air deposition was not a large problem. More recently, Larry Walker Associates completed a more in-depth analysis of the problem for the City of San Jose. Again, they estimated that air deposition accounts for only a small fraction of the total pollutant load.

The purpose of this report is to 1) review air monitoring activities conducted by the Bay Area Air Quality Management District, Air Resources Board, United States Geological Survey, and other agencies to determine if current monitoring is adequate for the needs of Bay Area Stormwater Management Agencies Association agencies, and 2) make recommendations for cooperative efforts between water quality and air quality agencies including additional sampling and analysis if appropriate.

This study estimated that atmospheric deposition contributes no more than 6% of the total pollutant load for any given metal, but this and previous studies did not involved anything more than rough calculations since there is little deposition data that is available. Collecting San Francisco Bay specific data of contaminant deposition is necessary before its importance to total contaminant loading into SF Bay can be determined.

This report recommends that the following studies be conducted:

1) Dry-deposition specific to San Francisco Bay. Deposition monitoring stations positioned on the surface of the San Francisco Bay would give much more accurate information than the estimates that are currently being generated.
2) Wet-deposition. There is plenty of monitoring of metal concentrations in the air, but no monitoring of metal concentrations in the rain.
3) Concentrations of pesticides in Bay Area air. This would give regulators an idea of whether air transport is a problem in this area.
4) Toxics in $PM_{2.5}$. This would separate the contaminants that are coming from anthropogenic sources as opposed to geological sources.
5) Barium as a good tracer of vehicle emissions as they move toward the Bay in runoff.
6) The speciation and toxicity of the pollutants falling directly onto water. This would indicate whether atmospheric deposition of contaminants is more important ecologically than non-point sources, even considering a lower percentage of total contaminant loading comes from deposition.

Title: **Parking Lot Monitoring Report**

Description: Road surface, parking lots, inlet filters

Project Number: C.2.1

Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: Mall parking lot, inlet filters, dissolved pollutants, sediment concentrations

Objectives: 1) characterize runoff water quality;

2) inlet filter effectiveness at a large mall parking lot in Santa Clara Valley

Woodward Clyde prepared for SCVNSPCP this report on characterization of runoff water quality from parking lots, test potentially feasible controls and develop guidance on control options. This report summarizes results of WQ and sediment sampling at a large mall parking lot in Santa Clara Valley during the wet season of 1995.

Samples were collected at four inlets and analyzed for metals, total petroleum hydrocarbons (TPH), total organic carbon (TOC) and total suspended solids (TSS). Runoff data, using median concentrations from eight grab samples (two storms x four stations), were compared with other land use areas in SC Valley and data from other parking lot studies.

Results showed metals concentrations in this parking lot runoff are lower than concentrations from industrial, residential and transportation land use areas sampled, but higher (except for Cr) than open space land use samples. No conclusions could be drawn from comparison of TPH and oil/grease sample data (most analyses results were at below method detection limits).

Only three other parking lot studies were found appropriate to compare with this SCV study. In general the SCV median data are similar to the other parking lot data, except in one study where Pb was higher and the percentage of dissolved metals was lower than SCV results.

Comparison of sediment in the SCV parking lot showed lower metal concentrations than sediments measured at three other studies in the Bay Area, except Ag was about the same. TPH concentrations were higher in the other three studies than in the SCV study. Because of overflows during storms it's unclear how much of the runoff was treated by the inlet filters. Sediment in the filters had a mean concentration of 3300 mg/kg (wet), enough to be hazardous for disposal in landfills.

This study concludes the pollutants in storm water runoff from parking lots are mainly in a dissolved phase, not particulate. BMPs need to be developed to address this. TPH levels were too low to be treated effectively by oil/water separators. Overall problems with clogging and flooding indicate the filters had a low hydraulic and loading capacity.

Title: **Evaluation of Storm Water Runoff from Parking Lots in San Mateo County**

Description: Road surface, parking lots, rainfall runoff

Project Number: C.2.2

Program of Organization Conducting Study: San Mateo Countywide Stormwater Pollution Prevention Program (STOPPP)

Contact:: Marty Stevenson, KLI (808) 661-1110

Key Words: Parking lot runoff, dissolved contaminants, particulate contaminants, sediment concentrations, storm water sampling, storm water monitoring

Objectives:
1) supplement existing data on the quality of parking lot runoff,
2) attempt to help clarify the question regarding whether or not settling/filtration-type BMPs are effective in treating parking lot runoff, and
3) assess temporal changes in trace metal composition from parking lot runoff.

KLI conducted this study as subcontractor to EOA for STOPPP to

1) supplement existing data on the quality of parking lot runoff,
2) attempt to help clarify the question regarding whether or not settling/filtration-type Best Management Practices (BMPs) are effective in treating parking lot runoff, and
3) to assess temporal changes in trace metal composition from parking lot runoff.

This study characterized the seasonal discharge and partitioning between dissolved and particulate fractions of contaminants in runoff from three parking lots within San Mateo County. The results of this study were compared to studies conducted on parking lots in other areas, such as Santa Clara County, Portland, Oregon, and another San Mateo County location.

When comparing runoff data among parking lots in San Mateo County and parking lots located in other regions, KLI found the following results:

1) Median concentrations of total recoverable copper, lead, and zinc are generally similar among sites that are geographically and environmental diverse.
2) Dissolved concentrations of copper, lead, and zinc are substantially lower in runoff from San Mateo County parking lots than a mall parking lot in Santa Clara County and a 35-acre parking lot located in Portland, Oregon.
3) Parking lot runoff from San Mateo County contains substantially higher concentrations of suspended solids than in other locations.

While a Santa Clara study concluded that the majority of metals in parking lot runoff are mainly in a dissolved phase, not particulate phase, this study found that 70% of the metals were present in the particulate form. As a result, KLI concluded that parking lots, particularly parking lots with high sediment loads, could be expected to benefit from implementation of settling/filtration BMPs.

Title: **Pollutant Concentrations in Catch Basins and Street Sweeping Sediments in Contra Costa County, 1993–1996**

Description: Evaluate catch basin and street sweeping sediment quality data and develop "typical concentration values" (TCVs) for estimating pollutants removed from catch basin cleaning and street sweeping activities.

Project Number: C.2.3

Program or Organization Conducting Study: Contra Costa Clean Water Program

Contact: Tom Dalziel (510) 313–2392

Key Words: catch basin, street sweeping sediments

Objective: Develop TCVs for estimating pollutants removed from catch basin cleaning and street sweeping activities.

Street sweeping and catch basin cleaning are among the best management practices (BMPs) that municipalities in the San Francisco Bay Area are implementing to reduce pollutant transport into receiving waters. Municipalities in Contra Costa County and other counties have been monitoring street sweeping and catch basin sediment quality for several years. The purpose of this study is to review municipal catch basin and street sweeping sediment data in order to evaluate the following questions:

1) How variable are the data?
2) Are there differences between sediments collected in land use catchments?
3) Are there differences between sediments collected by street sweeping and catch basin cleaning?
4) How do the Contra Costa data compare to data collected in other Bay Area counties?
5) What are the typical pollutant concentrations found in Contra Costa County?
6) Can this information be used to estimate pollutant quantities removed from catch basin cleaning and street sweeping? In other words, can we develop "typical concentration values" (TCVs) that could be multiplied by the weight of sediment removed to provide an estimate of the quantities of pollutants removed by these BMPs?

Following is a summary of results and recommendations provided from this study:

1) There was a high variability in Contra Costa County data.
2) Pollutant concentrations and sediments from different land use catchments and from the different BMPs fell within similar ranges, indicating there are not striking differences between these data groups. However, rigorous statistical comparisons could not be performed due to the limited amount of available data for catch basins in commercial and industrial land use catchments, and to the general sparsity of street sweeping data.
3) Pollutant concentrations found in Contra Costa County sediments appear to be similar to or lower than those found in Alameda County and the Cities of San Francisco and San Jose. In particular, copper concentrations are lower than those found in San Francisco catch basin sediments and San Jose street sweeping sediments, lead concentrations are lower than those found in San Francisco catch basin sediments and San Jose street sweeping sediments, and TPH concentrations are lower than in Alameda County catch basis sediments. Contra Costa County sediments exceed some of the other locations only in TPH concentrations in commercial catch basin sediments and in lead concentrations in residential and commercial catch basins.
4) Typical concentration values were developed for each of the pollutants based on a statistic derived from actual data, i.e., the mean concentration, but the numbers were rounded to facilitate use. The reliability of TCVs depends on the number and the representativeness of the samples used in their development, so the amount of available data dictated whether breakdown in land use specific TCVs is reasonable.

Title: **Roof Runoff Water Quality: A Literature Review ACURCWP 1994**

Description: Roofing materials

Project Number: C.3

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Jim Scanlin (510) 670–6548, Phil Mineart (510) 893–3600

Key Words: roofing materials

Objectives: Review literature assessing the significance of roof runoff as a source of pollutants

This review by Woodward Clyde for ACURCWP of studies in the literature assessed the significance of roof runoff as a source of pollutants. Two telephone surveys were conducted in addition. One survey to identify roof types and roofing materials used in Alameda Co. And the other survey to learn how roof runoff drains into municipal storm drain systems in Alameda Co. (how much of the drainage is directly connected to storm drains).

Results showed most roofing materials have substances that release pollutants to storm water. Asphalt is commonly used for water proofing. It contains metals and organics that may release or dissolve in wet weather and enter roof runoff. An EPA study (1978) showed corrosion of galvanized rain gutters and downspouts can contribute high Zn levels in runoff. In Alameda County much of roof runoff in residential areas infiltrates into the soil while most roof drainage in commercial/industrial areas drains directly into storm drain systems. Commercial/industrial is a minor portion compared to total residential area. But since current local policies encourage direct connection of roof drains to storm drains, pollutant contributions from roofing materials will grow.

No recommendations were made in this review.

Title: **Contribution of Heavy Metals to Storm Water from Automotive Disc Brake Pad Wear SCVNSPCP 1994**

Description: Brake pad composition

Project Number: C.4

Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: brake pad composition, storm water, disc brake pads, heavy metals

Objective: Develop loads model to estimate load of Cu, Zn, and Pb into south SF Bay from disc brake pads

The SCVNSPCP NPDES permit requires a source identification and control program for heavy metals. Brake pad wear was identified as a significant source in 1992 of Cu, Pb, and Zn to storm water loads into south San Francisco Bay. Using lab data Woodward Clyde developed a loads model to estimate the load of Cu, Zn, and Pb into south SF Bay from disc brake pads of seven auto manufacturers. Results also include a literature review and lab analysis of brake pad composition.

20 different brake pads were analyzed. Cu, Pb, and Zn concentrations varied widely. Cu content was measured to be as high as 20%, Pb content was as high as 12%, and Zn was as high as 18%. Some brands have low Cu, Pb and Zn content. Some foreign cars had disc brake pads with higher heavy metal concentrations. Loads model conclusions showed disc brake pads may be a significant source of Cu to storm water in Santa Clara Valley. Contributions of Pb and Zn were less. Non-domestic autos appear to contribute a larger load of Cu to storm water than domestic autos. The pads analyzed represent 79% of registered vehicles in SC Valley. Comparison to replacement brake pads was based on two brake pad models tested. Fate and transport issues were not addressed in this study.

No recommendations were made in this study.

Title: **1) Industrial and Residential Source identification**
In: ACURCWP Annual Monitoring Report 1991–92
2) BMP Effectiveness Monitoring
In: ACCWP Annual Monitoring Report 1993–94

Description Focused source identification field studies/methods

Project Number: C.5

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Jim Scanlin (510) 670–6548

Key Words: storm water runoff, industrial catchment, Oakland, sampling, watershed mapping

Objectives: 1) Compare an industrial and a residential watershed site using grab samples.
2) Assess loads from an industrial site with reported high concentrations of Zn in runoff.
3) Develop guidelines for detection of point source contributors to storm drains.

1) Woodward Clyde was contracted by ACURCWP to study an industrial watershed site in West Oakland and a residential site in West Berkeley. A composite sampler was located at the base of each site. An additional goal was to obtain guidelines to detecting point source contributors to storm sewer systems.

Grab samples were collected at different locations in the two watershed sites during storms. The results showed grab sample concentrations were generally less than composite samples.

Visual observation was effective for identification of possible pollution sources. The majority of runoff from streets and roofs seemed a relatively minor factor. There was more "rainbow" sheen in runoffs at the industrial site. Two local auto wreckers appeared to be major sources of oil runoff.

A galvanizing plant appeared to be a source of Zn contamination. Street stains indicated oil and other fluid dumpings were numerous. Soapy water from washing trucks was common.

Draft guidelines were developed to identify presence of point sources of concentration levels for Cr, Cu, Pb, Ni, and Zn. Many variables were discussed for these sites and the presence of these metals and compared with other sites to create these guidelines.

Sediment samples at the industrial site suggest point sources of Zn, Cd, Ag, and Hg present. Further investigation within this watershed should be done to determine the sources.

2) This study by Woodward Clyde for ACCWP assesses loads from an industrial site with reported high Zn concentrations in runoff. A source identification control study was implemented to verify and develop a control strategy.

Results indicate the major source was a metal galvanizer. The City of Oakland then developed several Best Management Practices (BMPs) in the catchment that included inspections, street sweeping, litter removal, No Dumping signs, solid waste reclamation and outreach to local businesses and the community.

Implementation of the BMPs began in 1993. Flow and WQ monitoring was conducted for five winters (1990 to 1994), using automated equipment. And separate grab samples for oil, grease and bacteria were collected. A trend of decreasing concentrations was seen for total and dissolved Zn, total Cu and total suspended solids (TSS).

Title: **Identification and Control of Toxicity in Storm Water Discharges to Urban Creeks Final Report 1995 for ACURCWP**

Description: TIE testing

Project Number: C.6

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Richard Wetzig (510) 670–6478

Key Words: Toxicity identification evaluation (TIE) testing, bioassay, toxicity control

Objectives:
1) Determine the levels, patterns, causes ,and sources of toxicity in storm water and what threat they pose to impacted water bodies
2) Determine best available tools to track toxicity in storm water runoff successfully and then recommend control strategies

S.R. Hansen Associates undertook a study from 1992 to 1994 for ACURCWP to learn what the levels, patterns (spatial and temporal), causes and sources of toxicity in storm water are and what threat they pose to impacted water bodies. The study aimed to successfully use available tools to track toxicity in storm water runoff. If successful then control strategies would be recommended.

The major findings and recommendations are summarized here:

1) With appropriate selection of a biomonitoring tool toxicity in streams in storm events can be tracked.
2) overall, grab samples seem better than composite samples in collecting storm water runoff.
3) It is better to screen storm water runoff samples for toxicity using chronic tests.
4) It is best to screen storm water runoff samples for toxicity at only the 100% concentrations.
5) Standard TIE procedures are directly applicable to storm water runoff samples - no modifications are needed.
6) It is best to perform chronic TIEs on storm water samples rather than acute TIEs.
7) It is best to initiate TIEs as soon as possible due to the potential for degradation of toxicants.
8) Diazinon is a “real” problem in urban creeks during storm events.
9) The diazinon problem may not be limited to storm events. Limited data showed it can persist in toxic concentrations in dry weather.
10) A PBO test for organophosphorous insecticides should be a standard addition to the test suite for Phase I TIEs.
11) rapid screening of storm runoff samples for organophosphorous insecticides using ELISA techniques may be a useful Phase II TIE procedure.

Actions were recommended for a control strategy to prevent diazinon toxicity in storm water and urban creeks:

1) verify the extent of diazinon toxicity in urban runoff;
2) compile diazinon use data;
3) develop diazinon control strategy;
4) implement pilot watershed study of the diazinon control strategy.

Title: **1992 Annual Monitoring Report, Volume III Element Report, Sec. 5.0**

Description: Erosion sources

Project Number: C.8

Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: erosion sources, anthropogenic activity, best management practices, sediments, Guadalupe River, Coyote Creek

Objectives:
1) Evaluate historical monitoring data to determine sources and fates of pollutants in storm water runoff
2) Determine sources of PAHs

Woodward Clyde reported to SCVNSPCP on an evaluation of historical monitoring data to determine sources and fates of pollutants in storm water runoff. The data were evaluated to

1) determine if suspended stream sediments were enriched in metals versus benthic stream, and suspended and benthic Bay sediments;
2) determine if metals are contributed to the suspended particulates from previously deposited stream sediments becoming re-suspended, or from new contributions being flushed into streams via surface runoff during storm events.

Results will indicate input of additional metals from surface runoff or re-suspension of previously deposited sediments on suspended particulates.

Results indicated suspended sediments are enriched in metals compared to benthic sediments for Cr, Cd, Cu, Pb, Ni, and Zn. This suggests there may be additional input of metals probably from surface runoff. Somewhat elevated Ni and Cr levels are likely from a localized source (soils) rather than urban sources.

Results of the comparison of suspended particulate metal concentrations in streams to suspended and benthic sediments in the south Bay indicate stream suspended particulates are enriched in metals compared to suspended or benthic Bay particulates during storm events, except for benthic Cr following four days of rainfall where the two were about equal. These results suggest metals in sediments discharged into the South Bay are removed either through desorption and dilution or through transport processes. Benthic sediment concentrations in streams and the Bay were essentially similar, suggesting little metal removal or enrichment.

To determine if metals in stream suspended particulates are converted to dissolved species in the Bay, monitoring data were used to calculate apparent partition coefficients for the six metals. Results indicate Santa Clara Valley streams have higher coefficients than the Bay for Cu, Cr, and Ni. This suggests some of the suspended sediment band of Cu, Cr, and Ni are solubilized upon discharge to the Bay. Comparison to Alameda Co. results show higher Ni and Cr coefficients in Santa Clara Valley. This supports an erosional source of these metals in the Guadalupe River and Coyote Creek watersheds.

No BMP suggestions are in this volume.

During FY 1991–92 monitoring programs, PAHs were measured in selected water samples. Texas A&M analyzed for 39 PAH compounds or isomers.

The results do not appear to agree with results anticipated from earlier cited literature. Heavier PAHs were found in stream samples, not at highway and industrial sites, as anticipated. Biodegradation and volatilization rates suggest lighter PAHs are subject to more rapid removal than heavier PAHs. The medium-weight, predominantly 3-ring PAHs in industrial and highway stations indicated motor oil drips from automobiles and trucks and fuel products.

Title: **Marsh Creek Watershed 1995 Mercury Assessment Project Final Report, March 1996**

Description: Abandoned mine runoff — Marsh Creek

Project Number: C.12

Program or Organization Conducting Study: Contra Costa Clean Water Program

Contact: Phil Harrington (510) 313–2271

Key Words: Mercury analysis, mine tailings and runoff, Marsh Creek, Mt. Diablo Mercury Mine

Objectives:
1) Identify major source of Hg in Marsh Creek watershed. Mitigation at this site is recommended
2) Determine levels of Hg in sediment, fish and invertebrates at Marsh Creek Reservoir

This project analyzed water and suspended sediments at 18 sites on the Marsh Creek. watershed during a high flow period for Hg presence. Concentrations were combined with flow data and relative mass balances were calculated to rank each of the tributaries. Analytical collections from groups of aquatic invertebrates and fish from the watershed supplemented the above data.

Results established that the Mt. Diablo Mercury Mine site is an overwhelming and ongoing Hg source to the watershed. 88% of total Hg input was traceable specifically to exposed tailings piles at the mine. Data indicates Hg from the tailings mobilized in a dissolved state that partitions on to particulates as it moves downstream. Mitigation efforts should be directed to the tailings site.

A species survey was done at Marsh Creek Reservoir. Hg samples were taken there from surface and deep sediment, and from muscle tissue of fish, and from composites from invertebrates. Most sediment samples showed 0.36 to 0.80 ppm Hg present. Edible fish in the reservoir showed 0.5 to 1.0 ppm muscle Hg present. Both figures are not unusual for this part of California.

The mercury data base for the Marsh Creek watershed is now established. Data could be improved with additional sampling in 1996 to help account for natural inter-annual variability. This study recommends the county obtain the strongest baseline data possible prior to mitigation work, and monitor indicator samples during the mitigation to assess effectiveness.

Title: **Microbial Indicator Study for San Mateo County STOPPP, 1995**

Description: Microbiological indicators testing

Project Number: C.15

Program or Organization Conducting Study: San Mateo Countywide Stormwater Pollution Prevention Program

Contact: Robert Copper, Bio Vir Labs (707) 747–5906

Key Words: microbiological indicator testing, coliforms

Objectives: 1) Determine feasibility of differentiating between human and animal bacterial indicators
2) Develop procedures

Eisenburg, Olivieri & Associates conducted a study for SMCSTOPPP to differentiate human versus animal bacterial indicators and if successful to develop procedures adaptable to most municipal labs. Six bacteria were chosen for the indicator suite: total coliforms, fecal coliforms, fecal streptococci, *Clostridium perfringens*, *Basteroides vulgatus,* and F*RNA Coliphage.

Results showed existing procedures for measurement of less common bacterial indicators were not appropriate. Specialized media developed for *C. perfringens* and *B. vulgatus* showed to be presumptive. Because of detergents and disinfectants in the water of the samples, spurious results developed. Examination of specific animal feces did not develop definitive patterns of bacterial indicators. Measurement of presence and number of male specific coliphage were inconclusive. The usefulness of the *Clostridium/Basteroideform* ratio and presence of male specific coliphage as useful indicators needs further study.

Title:	**Septic System Study**
Description:	Evaluation of septic systems for discharges to storm drainage facilities in Contra Costa County
Project Number:	C.18
Program or Organization Conducting Study:	Contra Costa Clean Water Program
Contact:	Beth Thayer (510) 253–4231
Key Words:	Septic system discharges, drinking water supplies, San Pablo Dam Reservoir
Objective:	To determine if failing septic systems impact storm water runoff and, ultimately, drinking water supplies in the San Pablo Dam Reservoir.

Specific tasks the study will address will include:

1) a description of septic systems locations within each jurisdiction;

2) identification of systems that are potentially failing; and,

3) development of management options to address failing systems.

This project is ongoing.

D. BMP EVALUATION

Title: **1) Pilot Study 2) Street Sweeping/Storm Inlet Modification Literature Review ACURCWP 1994**

Description: Street Sweeping

Project Number: D.3.1

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Jim Scanlin (510) 670–6548, Phil Mineart (510) 893–3600

Key Words: street sweeping, storm inlets, disposal practices, new technologies

Objectives:
1) Recommend modifications to municipal activities to help reduce pollutant loads to SF Bay
2) Review literature of street sweeping studies to quantify benefits of this procedure in reducing pollutant loads
3) Evaluate alternative levels of street sweeping
4) Review studies of alternative storm inlet retrofit designs

1) Woodward Clyde did a pilot study for ACURCWP that recommended modifying municipal activities to help reduce pollutant loads to San Francisco Bay, including street sweeping and frequency of storm drain inlet cleaning -before pollutants can be flushed into the Bay. This pilot study, done in FY 1992–93, tried to determine an optimal cleaning frequency and to learn pollutant concentrations in storm drain inlet sediments.

Data were collected on 60 inlets cleaned monthly, quarterly, semi annually or annually. The mass of sediment collected per inlet increased with cleaning frequency. Commercial zones had the highest concentrations of Zn and Cu. Residential zones had the lowest concentrations of Pb, while commercial and industrial zones were about equal. Total petroleum hydrocarbons (TPH) concentrations were highest in residential zones.

Pb concentrations mostly did not exceed hazardous waste criteria. High TPH concentrations may be due in part to road asphalt which is relatively inert. As the cost effectiveness of monthly inlet cleaning has not been established, the existing practice of annual cleaning is appropriate at this time (Tier I BMP). Monthly inspection and cleaning as necessary of inlets during the wet season is recommended (Tier II BMP). Other alternatives should be considered such as more emphasis on street sweeping.

2) Woodward Clyde conducted a literature review for ACURCWP of existing street sweeping studies to quantify benefits of this procedure in reducing pollutant loads, to evaluate alternative levels of street sweeping, and to review studies of water quality (WQ)benefits of alternative storm inlet retrofit designs.

Results showed effectiveness of street sweeping to improve WQ depends on a number of factors that vary greatly locally (accumulation rate, rainfall, cleaning frequency, dirt particle size, street condition, parking controls). Optimal sweeping frequency is closely related to accumulation rate and rainfall. The highest pollutant concentrations are on the smallest particles but these are a small part of the total pollutant mass.

This study recommends sweeping occur just before storms, as close in to the curb as possible, that aims to pick up small particles at the recommended sweeping speed. Parking controls improve the effectiveness of street sweepers. Cleaning frequencies of more than twice a month produces maximum pollutant reduction. Vacuum and regenerative air sweepers were more effective at removing finer particles. Retrofitting inlets provides added WQ benefits only if regular maintenance can be assured. Existing data suggest that street sweeping does not effectively reduce Cu loads to the Bay. No single street sweeper design clearly showed superior effectiveness at reducing Cu concentrations in runoff. Maximum pollutant removal by street sweeping occurs on a three-times-per-week schedule. “Hot spot” storm inlets retrofitted with filters

improves treatment capabilities if inspected on a monthly basis.

Title: **San Jose Street Sweeping Equipment Evaluation City of San Jose Environmental Services Dept. Nonpoint Source Program 1994**

Description: Street sweeping

Project Number: D.3.2

Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: street sweeping equipment, disposal practices, San Jose

Objective: Evaluate street sweeper brands and models for improved pollutant removal

Woodward Clyde prepared for the City of San Jose and SCVNPSPCP a study to evaluate select street sweeper brands and models for improved removal of pollutants compared to their existing broom sweepers. Emphasis was placed on evaluating Cu removal.

The sweepers evaluated were: 1) regenerative air; 2) broom; 3) new broom; and 4) old broom. Steps were implemented to equalize routes and sediment loads.

The results showed:

1) the regenerative air and new broom models removed a greater mass of sediment than the old broom models;
2) the regenerative air models picked up sediments with higher Cu concentrations than the broom sweepers tested;
3) air and the new broom models picked more Cu mass per curb mile than the old and other broom models.

Use of either regenerative air sweepers or the new broom sweeper would increase the Cu collected by street sweeping. A sweeper's ability to remove a range of particle sizes is important, especially the smaller particles as they have higher metal concentrations and probably mobilize easier during storm events.

Title: **Copper and Selenium in the Water Supply of the Santa Clara Valley**

Description: Metals in water supply, copper sulfate control

Project Number: D.6.1

Program or Organization Conducting Study: Copper and Selenium Steering Committee Water Supply and Wastewater Treatment Agencies Providing Service to Santa Clara Valley 1994

Contact: Frank Maitski (408) 265–2600

Key Words: copper sulfate control, algaecide, copper plumbing corrosion

Objectives: Determine background Cu and Se concentrations in water supply and their contributions to the treatment plant influent load

The SFBRWQCB requested that water purveyors quantify the amount of Cu and Se in background water supplies, the amounts of Cu from corrosion of Cu plumbing and use of copper sulfate as an algaecide; in order to develop a plan to reduce Cu from these sources.

The results of this study showed that background water supply is a relatively minimal Cu source to wastewater treatment plant influent (3 to 6%). About 50% of the total supply in the Santa Clara Valley is treated and this significantly reduces Cu. Improving current treatment standards would be prohibitively expensive.

The Santa Clara Valley Water District will investigate the effect of coagulation optimization on Cu removal at its treatment plants. A recommendation to reduce Cu amounts from corrosion is in a separate report along with results of the corrosion study for compliance with the Federal Lead and Copper Rule.

A review of copper sulfate used in the South Bay Aqueduct found no cost effective alternatives. This copper sulfate application accounts for <1% of the Cu in wastewater treatment plant influent. The search for alternatives will continue. The number and total amounts of copper sulfate applications continue to be reduced without reductions in algal control efficiency.

Se monitoring was conducted for each water supply source and at influents.

Results indicated most of the Se in the water supply is from groundwater sources. Concentrations were less than 1 µg/L in all samples. Water supply Se loading represents about 26% of the RWQCP influent loading.

Title: **Internal Corrosion Control Study Final Report 1994**

Description: Metals in water supply — corrosion

Project Number: D.6.2

Program or Organization Conducting Study: Santa Clara Valley Water District

Contact: Frank Maitski (408) 265–2600

Key Words: corrosion inhibitors, corrosion control, drinking water

Objective: Evaluate corrosion inhibitor treatments

Kennedy/Jenks did this study for SCVWD and Santa Clara County water purveyors in response to the Federal Lead and Copper Rule. Five tasks evaluated the corrosion inhibitor treatments of several zinc orthophosphate dosings and several pH adjustments.

It was noted that inhibitor adjustments to pipes do not directly address Cu discharge into San Francisco Bay through wastewater treatment plants. Pipe samples were from new pipes so corrosion rates were higher than from old pipes. Still it was found that inhibitors do reduce Cu corrosion. Data developed from the tests was used to make specific recommendations for inhibitors with each water purveyor in the SC Valley region.

With several of these purveyors, including the SCVWD, no inhibitors were recommended as their water did not exceed Action Limits for Pb or Cu. For the City of San Jose and other Hetch Hetchy users pH and alkalinity control is recommended for water received from the Hetch Hetchy System.

The last task recommended a diagnostic monitoring plan in the distribution systems of water purveyors. This baseline is necessary to determine how pH and alkalinity vary throughout their systems.

Title: **Alternative Roadside Vegetation Study – Final Progress Report**

Description: Alternative roadside vegetation

Project Number: D.7

Program or Organization Conducting Study: Contra Costa Clean Water Program

Contact: Linda Bulkeley (510) 313–2238

Key Words: Alternative roadside vegetation, Bear Creek Road, herbicide, erosion, sedimentation.

Objective: Test alternative roadside vegetation to better control erosion and sedimentation, and to reduce herbicide use

The purpose of this study was to develop alternative roadside vegetation that requires less pesticides, reduces erosion and sedimentation, and reduces fire hazard. This type of vegetation will reduce the amount of sediment and pesticides reaching the municipal storm water system. Baefsky and Associates, a resource management consultant, conducted the study for Contra Costa County. The project was also coordinated with the East Bay Municipal Utility District. The study site was four blocks on Bear Creek Road in the San Pablo Dam Reservoir watershed.

This year, the consultant planned, prepared, and installed test alternative vegetation. Instead of herbicide spraying, the consultant used mulching, green flaming, and manual weeding to eliminate undesirable vegetation. The first product of this study was a "How To" manual for agencies to use when revegetating roadsides.

Title: **Evaluation of Settling and Filtration Best Management Practices for Urban Washwater Runoff Final Report 1995 SMCSTOPPP**

Description: Filtration/settling best management practices

Project Number: D.8

Program or Organization Conducting Study: San Mateo Countywide Stormwater Pollution Prevention Program

Contact: Marty Stevenson, KLI (808) 661–1110

Key Words: filtration/settling effectiveness evaluation, mobile washing

Objectives: Recommend improvements to existing BMPs and recommend new ones to reduce pollutant loads to storm water conveyances, particularly in treating washwater

Kinnetic Labs Inc. prepared for the SMCSTOPPP Collaborative Monitoring Subcommittee this study to improve and develop BMPs to reduce pollutant loads to storm water conveyances; particularly settling and filtration in treating washwater and assessing implementation costs.

This study focused on washwater runoff from non-detergent hot water pressure washing of sidewalks and plazas with no oil present. After a lab evaluation of filtration media, two prototype settling/filtration washwater treatment systems were designed and tested. They were a catch basin sediment trap/filter insert system (CBFI) and a curbside wedge (open surface) settling filtration system (CWFS). Washwater samples from 15 locations were analyzed to determine total suspended solids (TSS) and particle size distribution in the water.

Results found TSS concentrations in the washwater samples ranged from <1000 to >4000 mg/l. Suspended particles were mostly sand and silt size of roughly equal amounts. Clay concentrations may have been underestimated. Lab testing showed that settling significantly removed suspended solids (up to 80%). Use of primary and secondary filters effectively reduced rapid clogging but provided only nominal reductions in suspended solids loading.

The CBFI and the CWFS about equally retained a significant part of the suspended solids. These results were comparable to lab test results. The CWFS functioned efficiently with just one or two wedges if bypass from filter clogging is prevented. Two primary filter fabrics, Trevira 011/200 and Wellman PN 060 both provided effective removal of floatable and coarser particles in the CBFI, and assisted settling in the CWFS.

Custom fabrication cost of the CBFI filter is between $1200 and $1500 while CWFS fabrication cost is about $100. The latter system is preferred because of lower cost, ease of operation and treatment efficiency. The data developed were used to develop a rough projection of total sediment loads, from sidewalk cleaning in an 8 hour work day, of approximately 10 lbs. of solids. Use of either BMP would remove about 8 lbs. of solids. Removal of pollutants other than TSS was not evaluated in this study, but should be evaluated in the future. This study recommends further study on optimization of settling as a primary treatment and evaluation of removal efficiencies for specific pollutants of concern.

Title: **General Guidance for Monitoring Effectiveness of Post-Construction Structural Best Management Practices ACURCWP 1995**

Description: Monitoring guidance for post-construction BMPs

Project Number: D.11.1

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Jim Scanlin (510) 670–6548, Chow Lee (510) 893–3600

Key Words: post-construction structural pollution control, directly connected impervious areas, pollutant removal, structural controls

Objective: Provide monitoring guidance for post construction structural pollution controls on new development and construction sites draining into municipal storm drain systems in sensitive areas

Woodward Clyde prepared for ACURCWP this monitoring guidance for their SWMP regulations for post construction structural pollution controls on new development and construction sites having more than five acres of "Directly Connected Impervious Area" (DCIA) draining into municipal storm drain systems in sensitive areas (less than 200 feet from a water quality resource).

Two monitoring types were described: 1) visual and 2) water quality (WQ) monitoring to ensure consistent and effective implementation. The types of structural control measures included were constructed wetlands, wet ponds, extended detention basins, oil-water separators, sand filters, grass swales, and combination systems. The visual inspections described here were pre storm inspections for damage and post storm inspections observing inlet and outlet structures, sediment accumulation, and color/clarity/floatable content of water.

WQ guidelines describe storm sampling, QA/QC, and evaluating pollutant removal effectiveness of the control. This last includes measurements at inflow and outflow streams during the same storms. Samplers from automatic flow-composite samplers should be analyzed for TSS; total and dissolved Cu, Cd, Pb, Ni, and Zn ; specific conductance; and pH. All data collected will be used to estimate pollutant removal effectiveness for each Best Management Practice (BMP). This guidance provides a tool to quantify removal effectiveness of each BMP, a way to prioritize the BMPs, and a way to improve the effectiveness of BMPs by selective retrofitting.

Title: **Guidance for Monitoring the Effectiveness of Stormwater Treatment Best Management Practices**

Description: Monitoring Guidance for BMPs—Treatment Controls

Project Number: D.11.2

Program or Organization Conducting Study: BASMAA

Contact: Geoff Brosseau (510) 622–2326

Key Words: Effectiveness of treatment control BMPs; transferability of monitoring results.

Objectives:
1) Review national and regional literature on monitoring BMP effectiveness
2) Recommend monitoring techniques and parameters to measure and report various types of post-construction BMPs

This review, prepared by EOA, Inc., describes the design of a BMP monitoring program, beginning with consideration of monitoring objectives, site characteristics, and study duration. Each monitoring program should have clearly defined goals and objectives and carefully designed strategies to achieve them. It is recommended that a monitoring program include a distribution of sampled events that is representative of the average annual event distribution and continue until sufficient data are collected for analysis. Recommendations for flow measurement and sampling include: Collection of flow-weighted composite samples for most parameters; collection of manual grab samples for oil and grease, TPHs, PAHs, VOCs, and bacteria; collection of samples from influent and effluent flows at locations that are as close to the treatment unit as possible. The study lists recommended parameters for assessing BMP performance and recommends an initial screening of a broad range of parameters at low detection limits to determine presence or absence. The review also provides descriptions of specific treatment BMPs (oil and sediment separators, sand filters, vegetated swales and filter strips, extend detention basins and constructed wetlands or ponds) and their pollutant removal capabilities, maintenance requirements, and recommended parameters to report. The review includes summaries of several recently completed or ongoing BMP monitoring studies in the Bay Area.

E. TREATMENT CONTROL MEASURES

Title: **Draft Technical Memorandum: Folsom/Huntwood or Quail Run Detention Basin Retrofitting Technical Feasibility Study FY 1993–94**

Description: Detention basin

Project Number: E.1.1

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Richard Wetzig (510) 670–6478

Key Words: detention basin, inlet/outlet design, Hayward, Newark

Objective: Evaluate the feasibility of retrofitting two flood control detention basins to provide water quality benefits

As part of their Storm Water Management Plan, ACURCWP evaluated the feasibility of retrofitting two existing flood control detention basins, Folsom/Huntwood in Hayward and Quail Run in Newark, to provide water quality benefits. Since Quail Run has a smaller drainage area (125 acres versus 169) but four times the basin volume (23 acre feet versus 5.5), it was the better candidate for successful retrofitting and so was examined more closely.

The redesign at Quail Run involved Changing the 24 inch outlet culvert into the inlet by removing the flap gate. Small flows will enter the detention basin by this route. Larger flows will continue to enter through the 24 inch culvert and over the weir. The 48 inch main trunk pipe will be blocked with a two ft. high weir to divert small flows to the 24 inch inlet.

The outlet size was calculated to 6.8 inches to provide a detention time of at least 40 hours in the basin. A six inch outlet will be installed inside the 24 inch inlet pipe and through the two ft. high weir blocking the main trunk. A trash rack will be installed on the basin side to prevent clogging.

This arrangement allows water from small storms to enter the basin, drop most of its sediment there and later flow back into the 48 inch main trunk pipe when water levels drop again. The basin still operates as a flood control facility to retain peak floods, including the 100 year/24 hour duration runoff volume.

The basin should be inspected yearly to determine if sediment removal is required. Inlet and outlet works and weir structures should also be maintained to prevent clogging. No other recommendations and no results were presented.

Title: **Sunnyvale Detention Basin Demonstration Project**

Description: detention basin

Project Number: E.1.2

Program or Organization Conducting Study: Santa Clara Valley Nonpoint Source Pollution Control Program

Contact: (800) 794–2482

Key Words: Detention basin, pump stations, retrofitting, treatment-based controls

Objective: A pilot study to evaluate implementation of retrofitting of a detention basin to improve pollutant removal capability

Woodward Clyde conducted this pilot study for SCVNSPCP in compliance with their NPDES permit to evaluate feasibility of implementing treatment-based controls by retrofit and testing of existing flood control detention basins. The study site was Sunnyvale Pump Station # 2 and its detention basin of 4.4 acres and 30 acre ft. capacity.

Retrofitting included three structural changes and one operational change. A gabion weir was installed at the outlet to reduce short circuiting, rock was dumped into the channel leading from the inlet, and a drainage pipe that ran below the channel was blocked. The pump schedule was modified to create a two-ft. permanent pool at the outlet to provide temporary storage and slow water release. WQ and hydrologic sampling were conducted during six storm events from '91 to '93 at the outlet and inlet sites. Three rounds of sediment samples characterized the basin sediment chemistry.

Results showed average percentages of removals were 29% for total Cd, 42% for total Cu, 53% for total Pb, 51% for total Ni, 44% for total Zn, and 50% for total suspended solids. Sediment concentrations were all well below hazardous waste criteria. These results suggest that suspended solids may be used as a surrogate parameter to monitor effectiveness of metals removal in detention basins. The cost effectiveness of this pilot for removing the metals was estimated as comparable to some other methods. The potential for significantly reducing heavy metal loads to SF Bay by retrofitting existing flood control facilities is minimal. For instance the net reductions of Cu, if all flood control facilities were retrofitted, would be about 100 lbs. per year, or less than 1% of the estimated mean annual Cu load to SF Bay. Results show that increased deposition caused by retrofitting in this basin did not increase flood risk.

Title: **DUST Marsh Special Study FY 1993–94 ACURCWP**

Description: Wetlands

Project Number: E.2

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Richard Wetzig (510) 670–6478, Revital Katznelson (510) 874–3048

Key Words: wetlands, treatment effectiveness, log baffle, wind, toxicity testing, storm water

Objective: Determine toxic substances in DUST Marsh

Woodward Clyde prepared for ACURCWP a report on continuing studies (since the '80s) of the Demonstration Urban Stormwater Runoff (DUST) Marsh system in Fremont Toxicity Identification Evaluations (TIEs) advanced to Phases II and III, pursuing the question: what is the toxic substance, is it consistently the same and the only toxic substance present?

The finding was that diazinon is consistently the toxic agent.

Source control measures can now be targeted and serve as a model in future evaluations. Continued monitoring showed the floating log baffle captured and slowed toxic storm water flow through the marsh allowing mixing with resident water. Continued monitoring showed the mixing process functioned well and was enhanced by wind at times. Further study may shed light on the role of wind in both mixing and sedimentation. Studies continued in the marsh on PAH analysis (effectively removed in Crandall Creek above the marsh), Se concentrations (no accumulations noted), and toxicity dilution (linear correspondence to LT50 values found). "In Situ" toxicity testing suggested elevated temperature and siltation rather than chemical toxicity caused mortality.

Knowledge gained at the DUST Marsh is transferable to similar systems designed to remove soluble pollutants and break down toxic organics. There is little evidence of elevation or accumulation of Cu, Pb, or Zn in the creek or marsh over time. Further studies are needed to confirm diazinon is removed from the system over time and that conservative elements, such as metals, do not pose long term risk to the ecosystem.

Title: **Vegetated Channel Studies ACURCWP 1994**

Description: Vegetated channels

Project Number: E.3.1

Program or Organization Conducting Study: Alameda County Public Works Agency, Alameda County Clean Water Program

Contact: Richard Wetzig (510) 670–6478, Francesca Demgen (510) 874–1731

Key Words: vegetated channels, design characteristics, channel maintenance, earthen channels

Objectives: Compare capacity of vegetated and earthen channels to uptake and accumulate metals and PAHs

This report was prepared by Woodward Clyde for ACURCWP, responding to Alameda County Stormwater Management Plan goals to reduce pollutants discharge receiving waters. In particular it describes further study and results of urban storm runoff flow into vegetated channels and earthen channels and their capacity for removal of metals and PAHs; one in San Leandro, one in Hayward, one in Union City, and one in Pleasanton.

Results showed concentrations in control plants and sediments significantly lower than plants and sediment in channels exposed to storm water runoff. This demonstrates active take up. Biomagnification and toxicity are not expressly addressed in this study. A review of related studies supports these results that vegetated flood control channels physically trap sediments that otherwise would enter SF Bay. There also was a decrease in PAH concentrations along a gradient from upstream to downstream in Crandall Creek.

This study recommends:

1) several species of emergent, floating and submerged vegetation (excluding woody plants) be allowed to grow in flood control channel bottoms as much as possible;
2) ways should be investigated to decrease the amount of sediment entering flood control channels;
3) make sediment core samples as free of excess water column water as possible;
4) do a cost-benefit analysis for enhancing sedimentation as an in-line pollutant removal mechanism;
5) sample to find the depth that urban runoff Cu, Pb and Zn are found in vegetated channel sediments;
6) do further analysis of Pb in sediment to determine if the Title 22 Hazardous Waste STLC limit are exceeded.

Title: **Sediment and Vegetation Concentrations of Copper, Lead and Zinc in Crandall Creek-DUST Marsh System**

Description: Vegetated channels

Project Number: E.3.1

Program or Organization Conducting Study: Alameda County Public Works Agency, Alameda County Clean Water Program

Contact: Richard Wetzig (510) 670–6478, Francesca Demgen (510) 874–1731

Key Words: vegetated channels, design characteristics, channel maintenance, earthen channels

Objectives: Determine pollutant removal at the DUST Marsh-Crandall Creek system

Woodward Clyde for the Alameda County Public Works Agency studied pollutant removal from urban runoff at the Demonstration Urban Stormwater Treatment (DUST) Marsh-Crandall Creek system near Coyote Hills in Alameda County. The DUST Marsh serves flood control and wildlife needs as well. It receives runoff from Fremont's Crandall Creek, in the City of Fremont.

Results showed sediment concentrations of Cu, Zn and Pb low in the DUST Marsh compared to Crandall Creek had lower bioavailability in the marsh.

New tests should show whether concentrations of Cu, Pb and Zn in surficial sediments of Crandall Creek. are highest close to storm sewer outfalls with concentrations decreasing downstream. This should show if rapid metals deposition is occurring there. A second objective will test the bioavailable fraction of Cu, Pb and Zn in Crandall Creek-DUST Marsh. A third objective will determine concentrations of Cu, Pb and Zn in the vegetation of the Crandall Creek-DUST Marsh system along some gradient of distance from storm water sewer discharge points. This document describes the methods, QA/QC, documentation and reporting conventions that will be used. No results of this described study are reported in this document.

Title:	**Monitoring Plan, Grassed Swales; Alviso Facility, Newark ACCWP 1996**
Description:	Vegetated swales
Project Number:	E.3.2
Program or Organization Conducting Study:	Alameda Countywide Clean Water Program
Contact:	Jim Scanlin (510) 670–6548
Key Words:	grassed swales, pollutant removal
Objective:	Evaluation of turfed swales as a BMP for removal of pollutants in the 1995–96 rainy season

This study conducted by Woodward Clyde for ACCWP is in progress. Turfed grass swales will be incorporated into the landscaping design of a new mail distribution facility in Newark as a recommended Best Management Practice (BMP) listed in California Storm Water BMP handbooks.

This pilot study will evaluate the effectiveness of turfed grass swales at the above site for removal of pollutants during the 1995–96 rainy season. Results are expected in the second half of 1996. There is little information in California on the Effectiveness of this treatment control method. This study will evaluate effectiveness in reducing pollutants loads and concentrations and develop a relationship between swale contact time and pollutant removal. This document includes a literature review, sampling rationale, methods, QA/QC, methodology to analyze results, and references.

Title: **Channing Diversion Project Storm Drain Interceptor Program**

Description: POTW pilot diversions

Project Number: E.9

Program or Organization Conducting Study: RWQCP - Palo Alto

Contact: Leo Sarmiento (415) 329–2292

Key Words: POTW pilot diversions, storm runoff

Objective: Describe a pilot project diverting storm water to the sanitary sewer for treatment.

This summary document describes the City of Palo Alto's implementation, as a co-permittee of SCVNSPCP, of a pilot project control measure designed to reduce pollutant discharge into storm drains, creeks and the Bay. The project diverts storm water runoff from a commercial area ("Channing Ave."—50 total acres) into the sanitary sewer.

The area has a number of vehicle repair shops. During light to moderate storm events, first hour and composite samples were collected to determine pollutant loading diverted from the storm drain system. Samples were analyzed for total and dissolved metals. Results describe pollutant concentrations diverted and water quality characteristics of the area.

Title:	**The "Eco>Flow" Filtration System—Summary Report and Test Data January 1996**
Description:	Post construction/new development BMPs
Project Number:	E.10
Program or Organization Conducting Study:	City of Clayton, Contra Costa Clean Water Program
Contact:	Randy Hatch (510) 672–6690
Key Words:	Prototype filtration system, Clayton, construction, residential runoff
Objective:	Describe a prototype test of a filtration system for reduction of pollutants at residential construction sites

The purpose of this study was to design, develop and test a control structure that filtered pollutants from storm water runoff generated by a 54-unit residential subdivision. The results of this study will help municipalities choose post-construction BMPs that eliminate pollutants from new development runoff. The study was conducted for the City of Clayton by Wollman Associates, Inc., an engineering consulting firm. During the 1995–96 permit year, a test model of the filtering system was designed and constructed. The filtering system was tested to measure its ability to remove pollutants. Test parameters included heavy metals, hydrocarbons, and oil and grease. The summary report for these tests is available in the BASMAA library.

The study is ongoing. The next recommended step is to conduct a full-scale box and filter system test in the City of Clayton.

Title: **Best Management Practice Effectiveness Test of the Jensen High Velocity Stormwater Interceptor**

Description: interceptors

Project Number: E.11.1

Program or Organization Conducting Study: San Mateo Countywide Stormwater Pollution Prevention Program

Contact: Marty Stevenson KLI (808) 661–1110

Key Words: BMP effectiveness, storm water interceptor, parking lot runoff, contaminant removal, performance testing.

Objectives:
1) estimate pollutant removal efficiency of Jensen storm water interceptors;
2) estimate volume treated compared to volume bypassed;
3) characterize quantity and quality of sediments accumulated in interceptor.

KLI conducted a study as subcontractor to EOA for the SMCSTOPPP to evaluate the effectiveness of the Jensen Precast High Velocity Storm Water Interceptor as a BMP to treat storm water runoff from parking lots. Study results led to the following conclusions:

1) The interceptor installed at a parking lot at Addison-Wesley Publishers in Menlo Park effectively removed total Cu, total Pb, and suspended solids throughout the study period of January 5 and April 9, 1996.
2) Removal efficiencies of Cd, Cu, Pb, and, to a lesser degree, Zn from storm water were strongly influenced by both the total concentration of each metal and the degree to which each metal was associated with the particulate fraction.
3) The concentration of trace metals in runoff from the 6.4-acre study site was typically highest during earlier monitored storm events and declined to lower, more consistent levels later in the wet season.
4) The contributions of TSS were higher during the initial monitored storm events due to erosion from the open area next to the parking lot and higher intensities of rainfall.
5) Trace metals in storm water runoff were most strongly associated with the particulate fraction in the early wet season.
6) Monitoring of trapped sediments confirmed that removal of particulates was greatest during the early portion of the wet season. PAHs were removed primarily during the early potion of the wet season.
7) Sediments trapped were predominantly coarse materials, consisting of 72-87% sand.

Additional information is needed from a variety of parking lot types in order to fully evaluate the most appropriate strategy for this form of BMP. Overall effectiveness was strongly linked to the degree of association of the various contaminants with the particulate fraction and the total concentration. Investigations should emphasize potential implications of seasonal accumulation of contaminants on parking lot surfaces, seasonal wash-off, and partitioning between dissolved and particulate fractions.

Title: **San Ramon Stormwater Interceptor Study Scope of Work**

Description: interceptors

Project Number: E.11.2

Program or Organization Conducting Study: Contra Costa Clean Water Program

Contact: Revital Katznelson (510) 874–3048, Joye Fukuda (510) 275–2331

Key Words: BMP, cost/benefit analysis, San Ramon, interceptors, parking lot runoff

Objective: Develop key questions regarding the performance of Jensen storm water interceptors in San Ramon and the methods and costs to produce answers

This study by Woodward Clyde identifies relevant questions about the performance of Jensen storm water interceptors installed to treat storm runoff in two parking lots in San Ramon. Answers will help evaluate and refine BMPs for the interceptors and analyze the cost/benefits of this technology.

This document divides the questions into five study components. The approach (tasks), requirements, assumptions and cost estimates are defined for each component. The components and costs are:

1) evaluating the effect of the interceptors in decreasing pollutant concentrations in initial phases of storms (cost—$40,000);
2) measuring the percentage of storm water captured by the interceptors throughout the storm events and assessing WQ at the inlet throughout the events (cost—$28,000);
3) monitoring the accumulation of pollutants in the interceptors throughout the seasons and estimating quantities of pollutants that can be removed by cleaning the units (cost—$32,000);
4) developing maintenance criteria and requirements (cost—$11,000)
5) cost/benefit analysis (cost—$7000).

Title: **Mathematical Modeling of the DUST Marsh**

Description: Storm water residence time and vertical mixing analysis

Project Number:

Sponsoring Program or Organization Conducting Study: Alameda County Flood Control and Water Conservation District

Contact: Obaid Khan, (510) 670–5771

Key Words: Wetland, Storm water treatment, DUST marsh, Mathematical model

Objectives:

1) Develop a mathematical model to simulate the hydrodynamics and conventional water quality including temperature, conductivity and dissolved oxygen of a marsh system
2) Explain how the DUST Marsh works and how to improve its performance by either changing physical configuration or installing physical devices to increase mixing
3) Modify the model to simulate the effects of various engineering alternatives for improving the performance of the marsh system

A laterally averaged two-dimensional hydrodynamics and water quality model was adapted to the DUST marsh. The model simulates the following processes in the marsh: surface current, baffle mixing, and wind mixing. It was calibrated with observed water level, temperature and salinity profiles during the storm from February 6 to 14 in 1994. The model was then used to evaluate the effects of environmental conditions and different structural modifications. The incoming storm water normally floats on the surface because it is less dense than the resident water. Wind stresses at the surface and internal stresses generated by water flow will help mix the layers vertically. However, these two factors alone are usually not sufficient to break the density stratification. A significant portion of the runoff can short circuit through the marsh unless the flow is impeded. The residence time of the runoff was used to evaluate the performance of the DUST Marsh. A longer residence time will allow the runoff more time for treatment so that it is considered to be better. The model showed that the floating log baffle was effective to increase the residence time of the runoff. Because most of the incoming storm water floated on the surface, the baffle forced the water to the bottom of the marsh and induced vertical mixing. The model also indicated that lowering the pipes near the bottom of the marsh was a very effective scheme to increase the residence time. In this case, the saline resident water at the bottom was released first which increased the capacity of the marsh.

Recommendations: For a salt water marsh, build the outlet pipes near the bottom and install floating baffles on the surface.

F. WATERSHED MANAGEMENT

Title: **The Developing Relationship Between Public Agencies and Volunteer Groups for Watershed Monitoring and Stewardship in the San Francisco Bay Area**

Description: Coordinated volunteer monitoring

Project Number: F.1.2

Program or Organization Conducting Study: San Francisco Bay Regional Water Quality Control Board, San Francisco Estuary Institute

Contact: Gwen Starrett (916) 657–0518

Key Words: volunteer monitoring, public watershed agencies, regional watershed network

Objectives:
1) Evaluate survey results and the regional interest in volunteer monitoring
2) Determine benefits of coordination of these groups with public agencies in a regional network

The current level of interest in volunteer watershed monitoring was assessed in a survey of public agency and volunteer monitoring groups conducted by SFRWQCB, SFEI and the SF Bay Volunteer Monitoring Steering Committee. All the above parties are working to develop a framework to facilitate local watershed stewardship. A Regional Watershed Network is being formed to promote and advance education, inventory and monitoring of watersheds in the region.

Results of the survey confirm that government and citizenry strongly support the concept of volunteer monitoring of the environment. Survey responses also indicate that the practical and ethical benefits of volunteer monitoring are not realized because of lack of standard protocols for data collection and reporting and lack of programs to train volunteers.

An important opportunity exists to create a regional organization of volunteers that works closely with government partners to gather proper data sets to develop and achieve appropriate environmental goals.

A regional watershed network coordinating monitoring efforts of public agency and volunteer groups has the potential to tremendously increase the flow of information, understanding and concerns about the environment.

Title: **Options for Strengthening Existing Institutional Arrangements for Watershed Protection of the San Francisco Estuary**

Description: Institutional approach

Project Number: F.4

Program or Organization Conducting Study: U.S. Environmental Protection Agency

Contact: Scott McCreary (510) 649–8008

Key Words: institutional implementation framework, watershed based planning and management

Objective: Develop recommendations to implement Storm Water Management Plans covering the SF Estuary

This is a working paper that establishes an institutional and legislative framework for watershed planning and management. Its roots are the Comprehensive Conservation and Management Plan for the San Francisco Estuary. To enhance implementation of Storm Water Management Plans, the General Plan Guidelines and the California Environmental Quality Act, the following recommendations are made:

1) Local government planning depts. collaborating with SFBRWQCB should use the SFBRWQCB model SWMP requirements with their local developers.
2) Local governments with assistance from SFBRWQCB should consolidate storm water ordinances into one comprehensive ordinance.
3) Local governments with the SFBRWQCB should redraw land use maps to accommodate watershed boundaries. GIS helps to accomplish this. Redrawing should emphasize minimizing impervious surfaces and control of nonpoint source pollution.
4) Local planning depts. and storm water agencies should implement Best Management Practices for flood control and reduction of nonpoint source pollution pro-actively.
5) Open space should be designated to include areas for study of watershed processes.
6) Watershed protection should be included in local development permit processes.
7) Vigilance should be maintained to ensure follow-through on watershed protection requirements. Reward developers' successes in watershed management improvements.
8) Revise guidelines at the local level to avoid unnecessary and duplicate efforts.

With impetus from the Clean Water Act and the Coastal Zone Management Act, the following suggestions are offered for continuing work:

1) Continue to refine the (CONCUR/PERC) General Plan Guidelines with related agencies.
2) Friends of the Estuary should seek a coalition with the Bay Vision Action Coalition.
3) Continue to advocate good legislation in Sacramento while SFBRWQCB, EPA Region Nine, BCDC etc. pick up more of the local initiatives.
4) Further pursue opportunities for collaboration at the local level.
5) A link to transportation decision makers may be useful.
6) Cities in the south Bay should collaborate further to reduce Cu discharge into SF Bay.

Title: **Annual Monitoring Report, FY 1993–94**

Description: Hydrology vs. water quality. Summary of 1988–1994 data

Project Number: F.8

Program or Organization Conducting Study: Alameda Countywide Clean Water Program

Contact: Jim Scanlin (510) 670–6548

Key Words: hydrologic parameters, water quality, Alameda Creek, Castro Valley Creek

Objectives: 1) Describe efforts to characterize storm water runoff discharges in Alameda county
2) Estimate pollutant loads delivered to SF Bay

This report updates annual efforts (since 1988) to characterize storm water runoff discharges in Alameda County and estimate pollutant loads delivered to San Francisco Bay.

Included are the long term continuing database, evaluating compliance with Water Quality Objectives and potential for toxic runoff, and comparison of historical WQs to the new EPA guidance. Management and public relations implications and recommendations for the future are also included.

Field monitoring included hydrologic monitoring of flow rates, wet weather WQ sampling and laboratory analysis, and bioassay toxicity testing. Results of the water year July 1993 to July 1994 showed below average precipitation. WQOs for maximum concentrations of total Cu, Pb and Zn were exceeded on Castro Valley Creek. This later location also exceeded chronic (continuous) concentration WQOs for Cu and Zn. Total Hg exceeded WQOs in both Alameda Creek. and Castro Valley Creek. For dissolved metals there were "chronic" exceedances for Cu, Pb and Hg at Castro Valley Creek. and Alameda Creek. Hg bioaccumulation in fish there was uncertain. Further measurements therefore are desirable. Bioassay toxicity testing showed most samples toxic (Castro Valley Creek. more so). For dissolved metals in acute exposures exceedance for Cu and Zn appeared at Castro Valley Creek. again. San Lorenzo Creek. had exceedances of the chronic dissolved Pb criterion.

A review of five years data on Castro Valley Creek. indicated that antecedent hydrologic conditions explain 50% of observed variability in total Cu concentrations.

An evaluation on the influence of PAHs as risks from storm events showed that four non-carcinogenic PAHs exhibited no WQO exceedances for any storm events at three storm stations. For seven carcinogenic PAHs, total concentrations exceeded WQOs for consumption by organisms but not for dissolved.

Monitoring of a BMP at an industrial catchment in Oakland showed significant concentrations reduction for total dissolved Zn and total Cu.

Even with exceedances noted above, overall Castro Valley Creek. exceedances were mostly due to low water hardness. The new 1995 EPA standards reflect less concern. But San Lorenzo Creek. has chronic Pb exceedances. New criteria suggest that previous comparisons overestimated the toxicity impact of metals on Alameda Co. streams. Storm event monitoring emphasis should continue to be placed on toxicity due to other compounds. PAHs and processes like eutrophication continue to be a concern. It was not clear if brief exceedances of Hg and PAH are long enough to bioaccumulate in fish. Fish tissue analysis is recommended. Based on current information recharge of aquifers by Alameda Creek. is not a problem, nor is water and aquatic organisms consumption there. Further use of adequate detention basins reduce Cu by 30% and Pb by 50% in storm water. Vegetated swales and channels offer better treatment yet.

Overall this study indicated antecedent flow is significantly related to flow weighted total Cu concentration. It is recommended that hydrologic records be used to calculate flow compensated Cu. Some of the metals transported in streams deposited in streambeds. Estimation of how much that

fraction is would be difficult. It is recommended that further research be lead by the EPA for development of chemical translators for storm water

Title: **Geographic Information System**

Description: Transfer computer aided design (CAD) format storm drainage inventory files to a Geographic Information System (GIS) format

Project Number: F.9

Program or Organization Conducting Study: Contra Costa Clean Water Program

Contact: Jack Hall, (510) 779–7035

Key Words: GIS, CAD, storm drainage inventory

Objective: Examine the feasibility of transforming storm drainage inventory files from a computer aided design (CAD) format to a Geographic Information System (GIS) format.

Municipalities in the Contra Costa Clean Program had their storm drainage inventory digitized as part of the Part I NPDES Permit Application process. These files are available to cities within the county, accurate and detailed parcel maps in MicroStation format. These MicroStation files are updated each time a city submits a parcel change. The City of Antioch uses the County's MicroStation files on a regular basis. However, a much broader use of the mapping data has been identified. In order for these needs to be met, the maps must be converted into a PC based, user friendly GIS format such as ArcView by ESRI. With an ArcView based GIS, the City of Antioch can begin to use the data to streamline its surface water modeling, facilitate the NPDES permitting process, as well as other uses. This special study will document the conversion process for use by the nineteen (19) members of the Contra Costa Clean Water Program and demonstrate the usefulness of such a system by developing a theme in the GIS to show pervious and impervious land uses within the commercial and industrial areas of Antioch. This project is ongoing.

Title: **Castro Valley Water Quality Modeling**

Description: SWMM model calibration and verification

Project Number:

Sponsoring Program or Organization Conducting Study: Alameda County Flood Control and Water Conservation District

Contact: Obaid Khan, (510) 670–5771

Key Words: Modeling, SWMM, Castro Valley

Objective: To calibrate and verify an urban runoff model to accurately simulate the hydrologic processes of a watershed, particularly the quantity and quality of urban storm water runoff

The Storm Water Management Model (SWMM) was calibrated and verified on Castro Valley, California, a 5.5 square mile watershed with a long term historical database. The watershed was divided into 14 hydrologic units, each of which had different geographic characteristics. The model simulated the hydrological processes of precipitation, evapotranspiration, surface storage, infiltration, soil moisture, surface runoff, and channel flow from the upstream to the downstream hydrologic units. It also simulated pollutant accumulation, wash-off, and decay. A systematic calibration was performed. Data from 1979–81 were used to specify pollutant loading rates for street surfaces. The data set from 1989–90 was used to calibrate the quantity and quality of storm water. One different data set from 1993–94 was used to verify the model. The simulation was performed continuously over an extended period of time i.e. 2 years. The output was a time series of flows and pollutant concentrations. This output was compared to the observed data. On an annual basis, the match between the model and the data was remarkably close. The discrepancy was less 0.3 to 2.6% for hydrology, 7 to 17% for total suspended solids, 4 to 4.5% for copper, and 23 to 42% for lead. Precipitation was found to be the most dominant factor for the model simulation of runoff. The uncertainty of the distribution of precipitation over the watershed, which includes hill and low land areas, hampered a better match between the simulated and observed hydrographs.

Recommendations:

1) Long term and multiple years simulation be conducted;
2) Model application be expanded to other watersheds in Alameda County;
3) Deposition, accumulation and wash-off rates be investigated further for improved evaluation of best management practices;
4) Modify storm water sampling techniques to accommodate direct usage of data for model applications.

ACRONYMS AND ABBREVIATIONS

ACCWP	Alameda Countywide Clean Water Program
ACURCWP	Alameda Countywide Urban Runoff Clean Water Program
BASMAA	Bay Area Stormwater Management Agencies Association
BCDC	Bay Conservation Development Commission
BMP	Best Management Practices
CBFI	Catch Basin Sediment Trap/Filter Insert System
CCCWP	Contra Costa Clean Water Program
CWFS	Curbside Wedge Settling Filtration System
DUST Marsh	Demonstration Urban Stormwater Treatment Marsh
EDI	Equal Discharge Increment
EPA	Environmental Protection Agency
GIS	Geographic Information System
NPDES	National Pollutant Discharge Elimination System
POTW	Publicly Owned Treatment Works
QA/QC	Quality Assurance/Quality Control
RWQCB	Regional Water Quality Control Board
SCM	Source Control Measures
SCV	Santa Clara Valley
SCVNSPCP	Santa Clara Valley Nonpoint Source Pollution Control Program
SCVWD	Santa Clara Valley Water District
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SFEI	San Francisco Estuary Institute
SMCSTOPPP	San Mateo Countywide Stormwater Pollution Prevention Program
SOP	Standard Operating Procedure
SWMM	Storm Water Management Model
SWMP	Storm Water Management Plans
TIE	Toxicity Identification Evaluations
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
WQO	Water Quality Objective

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