MAMAGEMENT & IMPLEMENTATION PLAN – VOLUME II
TECHNICAL APPENDICES

Prepared by: The Steering Committee, City and County of Honolulu, State of Hawai‘i

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CITY-DOH PROJECT AGREEMENT

The following projects will be funded from the escrow governed by the Escrow Agreement between the City and County of Honolulu ("City"), Hawaiian Trust Company, Limited ("HTC"), and the Department of Health, State of Hawaii ("DOH"), Dated May 29, 1995, Account No. 185030251, Account Name "Hawaiian Trust Company, Limited, as Escrow Agent for City and County of Honolulu, U.S.A. and State of Hawaii and Lawrence Milka, M.D. v. City and County of Honolulu," as amended.

Funding of the projects from the escrow shall be conditional upon approval of these projects by the U.S. District Court for Hawaii.

The Escrow Agreement shall be amended to attach this Project Agreement as an Exhibit, to the extent that the U.S. District Court of Hawaii shall approve, or approve with amendments, the projects below.

The projects will be implemented as described below.

I. Ala Wai Canal Watershed ("ANCHW") Water Quality Improvement Project

Estimated cost: $150,000

A. Mission: Improve the quality of both surface waters and ground waters in the drainage basins for Manoa, Palolo and Hakiki Streams, and in the Ala Wai Canal through a long term, community-based, public-private program of non-point source management activities in the watershed.

B. Project Goals:

1. Improve the water quality of surface and ground waters in the drainage basins for Manoa, Palolo and Hakiki Streams, and in the Ala Wai Canal.

   a. The long term (5 years and longer) goal is to make measurable progress toward meeting state water quality standards for the Canal and the streams.

   b. The short and intermediate term goals are to improve the aesthetic and recreational values of the waters (e.g. remove and prevent litter and dumping into and next to the waters) and to implement best management practices to improve water quality.

PROJECT AGREEMENT EXHIBIT A, Page 1
2. Choose the appropriate means to improve water quality through a process that coordinates City, State, and Federal agencies, and incorporates public participation.

Watershed management organizes stakeholders to identify community values, problems, and best management practices (BMPs) to solve problems; to implement BMPs; and to monitor BMPs' effectiveness.

All options may be considered, although implementation will depend on agencies' jurisdictions and resources, and the options include:

a. Controlling and reducing erosion and sediment;
b. Reducing use of fertilizers and pesticides;
c. Reducing illegal dumping and litter accumulations in streams;
d. Re-vegetating stream banks where possible;
e. Inspecting and enforcing municipal stormwater permit conditions and grading-and-grubbing permit conditions;
f. Dredging of the Canal;
g. Increasing flushing rates in the Canal;
h. Minimizing raw sewage leaks or spills, and sewer areas on cesspools or septic systems; and
i. Coordinating with the DOH School-based Volunteer Water Quality Monitoring Project.

C. City and DOH responsibilities:

1. The City and DOH shall jointly select a Management Coordinator ("coordinator").

2. DOH shall retain and properly supervise a Management Coordinator ("coordinator") to ensure compliance with the requirements of this project.

3. The DOH shall approve payments from the escrow identified above to fund the coordinator's

PROJECT AGREEMENT EXHIBIT A, Page 2
retention and appropriate costs related to the coordinator and the implementation of this project (including implementing BMPs, testing their effectiveness, and laboratory analyses).

a. Payment shall be conditional upon satisfactory progress and completion of work for this project in accordance with this agreement.

b. Total payments shall not exceed the limit of estimated cost, above.

D. Project Benchmarks and Deadlines:

1. The City and DOH shall select the coordinator, and DOH shall retain the coordinator.

1a. The coordinator, working jointly with DOH and the City, shall establish deadlines for the items listed below, so that final Steering Committee Management and Implementation Plans can be completed in two years, as required by section G.4.m, below.

2. The coordinator, working jointly with the DOH and the City, shall establish an Ala Wai Canal Watershed Steering Committee.

a. First joint solicitation by the coordinator, City, and DOH of community participants to be on Ala Wai Canal Watershed Management Committee ("Steering Committee");

b. Establishment of the Steering Committee;

c. First meeting of Steering Committee;

3. The coordinator and steering Committee shall select sites for implementing and evaluating BMPs to the maximum extent practicable.

4. The coordinator and Steering Committee shall start and finish the first volunteer project for monitoring the effectiveness of BMPs.

5. If requested by the DOH/coordinator/Steering Committee the City shall perform before-and-after and upstream/downstream water quality monitoring by field observations to evaluate effectiveness of:

PROJECT AGREEMENT

EXHIBIT A, Page 3
a. The BMPs; and

b. Any other projects chosen for implementation.

This monitoring is not intended to replace routine or other DOH monitoring.

6. If requested by the DOH/coordinator/Steering Committee, the escrow fund may be used to pay for lab analyses of water quality samples on an as needed basis.

7. The Steering Committee shall submit to the City and DOH draft Ala Wai Canal Watershed management and implementation plans:

a. The Steering Committee shall recommend which Best Management Practices (BMPs) need to be implemented and where;

b. The Steering Committee shall consider any available water quality data and reports, and results of any volunteer monitoring project in making the recommendation.

8. The Steering Committee shall publish notice of the plans, solicit written comments, and hold public hearings on the draft plans.

a. The first notice shall be published on:

9. The Steering Committee shall submit to the City and DOH its recommended final Ala Wai Canal Watershed management and implementation plans:

E. Ala Wai Canal Watershed Steering Committee

1. The Steering Committee will be a focal point for a long term, community-based, public-private program of non-point source management activities in the watershed.

2. Steering Committee shall be chaired by the coordinator and shall consist of representatives from relevant State, City, and federal agencies, the University of Hawaii, environmental groups, the regulated community, interested community groups, and the public.

3. The Steering Committee, with its members' and the coordinator's help, shall reach out to the public and encourage public participation.
4. The Steering Committee may set up separate watersheds management committees in each of the three major drainage basins in the Ala Wai Canal Watershed - Manoa, Makiki and Palolo. Each basin committee could elect a chairperson, who could guide the local group and attend Steering Committee meetings.

5. The Steering Committee shall produce a Watershed Management Plan and an Implementation Plan, which may be combined, which shall recommend management measures, and explain how they will be implemented, to achieve project goals.

a. The Steering Committee shall produce at least one draft of management and implementation plans for City, DOH, and public review before adopting its final recommendations.

b. The draft plans shall be submitted for review before the end of the term of the Management Coordinator.

F. Public outreach and participation

1. Public outreach shall inform local residents of ongoing and planned watershed management activities; the ways in which these activities benefit the community; and encourage people to participate. After establishment of the Steering Committee, such encouragement shall include incentive programs (contests, awards, etc.).

2. The nature and amount of public participation shall be documented.

G. Management Coordinator ("Coordinator")

1. Selection. The coordinator will be selected jointly by DOH and the City.

2. Term. The coordinator will be retained for at least two years.

3. Supervision. The DOH will supervise the coordinator.

4. Major responsibilities:

a. The coordinator shall work jointly with the City and DOH to establish the Steering Committee.
b. The coordinator shall serve as chair of the Steering Committee and plan, organize and conduct the meetings.

If the Steering Committee forms subcommittees or basin committees, the coordinator shall coordinate and integrate their work.

c. The coordinator shall work directly with relevant State departments. E.g.

1) The Department of Health (DOH), especially staff working on Ala Wai Canal watershed management projects underway as part of the State/EPA integrated water program workplan for the Ala Wai Canal (Clean Water Branch, Safe Drinking Water Branch, Wastewater Branch, and Environmental Planning Office - Nonpoint Source Pollution Control, Groundwater Protection, and Water Quality Standards Programs);

2) The Department of Land and Natural Resources (DLNR);

3) The Department of Transportation (DOT);

4) The University of Hawai‘i (UH);

5) The Department of Agriculture (DOA); and

6) The Department of Education (DOE).

d. The coordinator shall work directly with the relevant City departments. E.g.

1) The Department of Public Works (DPW), especially with the Division of Engineering, Storm Water Quality Section, on the implementation of the water quality management plan within the Ala Wai Watershed as outlined in the City’s storm water NPDES permit requirements.

2) The Department of Transportation Services (DTS);

3) The Department of Parks and Recreation (DP&R);
4) The Office of Waikiki Development;
5) The Building Department; and
6) The Department of Wastewater Management.

e. The coordinator shall work directly with relevant federal agencies.

f. The coordinator shall develop and implement public outreach and public participation activities, both for setting up the Steering Committee and to help the Steering Committee after it is formed.

The coordinator shall document the nature and amount of public participation.

g. The coordinator shall assist in reviewing volunteer monitoring, applied research, and project implementation proposals. The coordinator shall be or become familiar with prior work done on the Ala Wai Canal Watershed to avoid unnecessary duplications of effort. E.g.

"Revised Total Maximum Daily Load Estimates for Six Water Quality Limited Segments on Oahu," W. Freeman (Nov. 1993)


h. The coordinator shall summarize information in reports from different monitoring and management projects in progress in the Ala Wai Canal Watershed and keep all interested parties informed of results on at least a quarterly basis.

i. The coordinator shall coordinate contractual projects in the Ala Wai Canal watershed and develop timetables to achieve projected benchmarks and schedules.

PROJECT AGREEMENT

EXHIBIT A, Page 7
j. The coordinator shall provide quarterly reports to the Chief Engineer and DOH on progress toward meeting project goals, benchmarks, and schedules.

k. The coordinator shall help the Steering Committee develop a watershed management plan and accompanying implementation plan that explains how the recommended management measures will be implemented in the watershed.

l. The coordinator shall present a written draft of the Steering Committee watershed management and implementation plan to the City, DOH, and the public for review before the end of the coordinator's contract.

m. The coordinator shall present the final Steering Committee management and implementation plans to the City and DOH.
2. Ultraviolet disinfection research ("UV") project.

Estimated cost: $70,000.

A. Project goal: Determine the characteristics of effluent from wastewater treatment facilities on Oahu to determine the suitability of those wastewater effluents for disinfection by ultraviolet (UV) radiation. The Kailua Regional WWTP is excepted because UV disinfection for it is being covered in a separate case, GOBB v. CITY, U.S.D.Ct. Civ., No. 92-00263 DAE. The goal is not to determine whether UV disinfection is feasible in the abstract, but to determine which specific treatment facilities can use UV disinfection. The details of the UV project are described in the proposal attached as Exhibit "UV."

1. Contingency. The scope of the UV project will be reevaluated after the Hamala Bay Study Commission releases its report. The report may address the need for disinfection of effluent discharged into Hamala Bay and may have implications for discharges elsewhere. The report is expected to be released on September 30, 1995.

B. Researcher: The DOH will contract directly with the University of Hawaii Water Resources Research Center (UH WRRC) for the research. The research will be subject to peer review during the research design stage and after project completion.

C. Schedule: The research report shall be submitted to DOH within 18 months after the project contract is signed.

3. Contingencies.

A. $30,000 shall be held in reserve to be applied to the UV project, only if and to the extent that UH WRRC in writing justifies to the satisfaction of DOH and the City, the need for additional expenditures to complete the UV project. Any such DOH and City approval shall be in writing.

B. Any part of the $30,000 held in reserve and not spent on the UV project shall be used to supplement the Ala Wai Canal Watershed water quality improvement project in ways consistent with that project and jointly approved by DOH and the City in writing.
Executed this 27th day of September, 1995.

CITY AND COUNTY OF HONOLULU:

By: 
RUSSELL M. MIYAKE
Director of Finance
City and County of Honolulu

By: 
FELIX R. LIMTIAKO
Director of Wastewater Management
City and County of Honolulu

By: 
KENNETH SPRAGUE
Director of Public Works
City and County of Honolulu

STATE OF HAWAII
DEPARTMENT OF HEALTH

By: 
BRUCE S. ANDERSON
Deputy Director of Health

APPROVED AS TO FORM AND LEGALITY

DUANE PANG
Deputy Corporation Counsel

LAURENCE K. LAM
Deputy Attorney General

PROJECT AGREEMENT

EXHIBIT A, Page 10
APPENDIX B

LIST OF STEERING COMMITTEE MEMBERS
### STEERING COMMITTEE MEMBERS

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APPLENDIX C

BEST MANAGEMENT PRACTICES (BMP) WORKSHOP REPORT
Best Management Practices Workshop

A summary of the workshop with papers and materials submitted by participants

Held AT
Ala Wai Canal Watershed Water Quality Improvement Project
February 27 (Thursday), 1997 — 8:00 AM to 4:00 PM
CONTENTS – Appendix C -- BMP Workshop

A Schedule of Presenters
B Summary of BMP Workshop Presentations, Questions and Answers
C Water Quality Standards in the Ala Wai Canal Watershed, Gordon Smith, Department of Health, Environmental Planning Office
D Criteria for Handling Drainage Discharge from Buildings and Appurtenant Structures, Gerald Takayasu, Chief, Storm Water Section, Department of Public Works, City & County of Honolulu
E Suggested BMPs for Litter and Debris Problems, Alex Ho, Environmental Engineer, DPW, C&C
G Contaminants: Sources, problems, typical BMPs, Eugene Akazawa, Clean Water Branch, DOH.
H Streambank Vegetation BMPs, and Vegetation Types Suitable for the Ala Wai Canal Watershed, Lisa Farrantinos, Watershed Consultant.
I Contribution of Stream Channel Erosion to Sediment Yield from an Urbanizing Watershed, June Harrigan, Ph.D., DOH.
J Suspended Sediment Production from Forested Watersheds on Oahu, Hawaii, Submitted by U.S. Forest Service and DLNR Division of Forestry.
K Channel-Lock: Flexible Concrete Revetment, Manufacturer's Literature.
L Copper, Brake Pads, & Water Quality, City of Palo Alto, DPW.
M Waikakalua Stream Realignment Project, Troy Ogasawara, Hawaiian Fertilizer Sales.
N Port of Seattle Study Recommends that Sweepers Can Replace More Expensive BMP's for Removing Metals, Jackie Parnell, Environmental Planning Consultant, Honolulu.
O Volunteer Monitors Aspire to Better Data
Q Stockpile Runoff Project – Chromium Leachate Exceeded Standards, Khal Spenser, UH.
R Trapping Metals in Stormwater from Highway Runoff.
S Metal Removal from Stormwater in Street Storm Drain Catch Basins – Fossil Filters
T List of Manufacturers Contacts for Storm Water Treatment Devices, per Joanne McLaughlin.
U Aquashield Stormwater Filters for Street Storm Drain Catch Basins
V Stormceptor Stormwater Filters for Street Storm Drain Catch Basins
W Timari Pavement Grease & Oil Waterless Cleaner. Honolulu, David Buck
A Schedule of Presentors
<table>
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<tr>
<th>TIME</th>
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<th>AGENCY</th>
<th>Paper</th>
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<tr>
<td>8:30 to</td>
<td>Introduction and Purpose of Meeting: Identify BMPs (Best Management Practices) for the Ala Wai Canal Watershed to Improve Water Quality in the Canal and in the Streams (Palolo, Manoa and Mānākalii).</td>
<td>Gene Dashiel</td>
<td>Yes, summary report.</td>
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<td>8:45 to</td>
<td>PANEL: Users and Uses of the Ala Wai Canal &amp; Watershed Streams -- Water Quality Goals. The Canal serves as an urban storm drain. Its water quality must meet certain standards for: 1) recreational users (swimmers and fishers); 2) passive uses (people who view or smell the canal); ocean receiving waters (floating debris kills ocean mammals, birds and fish).</td>
<td>DOH -- Gordon Smith</td>
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<td>9:30</td>
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<td>DPR -- Tony Hildebrand</td>
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<td>9:40 to</td>
<td>PANEL: Urban Stream Restoration: Symbolic &amp; Practical Importance to a Cleaner Canal. Improvement of the stream water quality is vital pre-requisite to improved Canal water quality. Stream restoration will add beauty to the urban environment and create long-term awareness in the community for the need for clean water.</td>
<td>Oahu/Canoe Racing Assoc -- Mike Tonga</td>
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<td>DAR -- Mike Yamamoto</td>
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<td>10:20 to</td>
<td>PANEL: Contaminants: Sources, Problems, Typical BMPs. Diesel and chlorinated from termiteicides; lead and other metals from vehicles; litter and debris from streets; metals and sediment in filling the Canal; and unhealthy bacteria are some of the contaminants in the Canal and streams. What are some of the Best Management Practices we can begin to apply? How effective will these initial measures be? What do we need to do for the longer term? Need more data? Need more money for remedial measures?</td>
<td>Pesticides -- DOA -- Gerald Kiro</td>
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<td>11:30</td>
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<td>Vehicles -- DPW -- Gerald Takayasu</td>
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<td>Litter and Debris -- DPW -- Alex Ho</td>
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<td>11:30</td>
<td>Lunch</td>
<td>Metals &amp; Sediment -- UH -- Khalil Spencer</td>
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<td>Bacteria -- DOH -- Eugene Akatsawa</td>
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<td>1:00 to</td>
<td>Vegetation -- for buffers and erosion control -- addition vegetation for ground cover to prevent erosion and to filter storm runoff is one of our top BMPs. What plants are best?</td>
<td>Keynote Panel: Watershed Financing and Governmental Structure. How can recurring infrastructure costs be funded? Would a watershed governance body make sense in this situation?</td>
<td>Peter Kaianiu, Economist; RE2 Casey Jamran, Attorney (U.H. Law School) and State Land Use Commissioner</td>
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<td>2:25 to</td>
<td>Flooding Impacts -- The existing stream network (and the Ala Wai Canal) are flood control structures. How to keep recreational and water quality objectives?</td>
<td>Structural erosion control -- Some situations may undergo such erosion force (certain stream banks) that vegetation alone cannot withstand high velocity water flow. What structural measures (short of concrete lining) are available to us as environmental options?</td>
<td>NHC -- Shirley Nakamura, Chris Smith J. P. Errett Inc. -- Lee Ann Errett</td>
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<td>Storm Drains - Can we retard storm runoff before it reaches the drains? Can we filter the runoff? How do we approach the massive complexity of the storm drainage system to improve water quality?</td>
<td>Youth for Environmental Service DLNR/Forestry/Ha Ala Hele</td>
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<td>DPW/Drainage Div. (Richard Suzuki) USGS (Bryan Hill)</td>
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<td>DAR (Mike Yamamoto) USFWS/Chris Willis</td>
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<td>DPW (Gerald Takayasu) DOH (Alec Wong)</td>
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B  Summary of BMP Workshop Presentations, Questions and Answers
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<tr>
<td>#1</td>
<td>Water quality studies to support diagnostic and lead to BMPs.</td>
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<td>#2</td>
<td>Designated uses (i.e. impaired by management, use, or public policy).</td>
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<td>#3</td>
<td>Water quality criteria to support impaired status.</td>
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**BMPs:**
- **A.** BMPs will be included in the Plan and used on or after October 1, 1997.
- **B.** BMPs will be implemented by the NPS, NRI, and other relevant agencies.
- **C.** BMPs will be evaluated for effectiveness and adjusted as needed.
- **D.** BMPs will be reviewed and updated on a regular basis.

**Question:** What does the Ala Wai Canal water quality mean?

**Answer:** The Ala Wai Canal is a submerged stream that flows through the city of Honolulu. It carries sewage from the city and is an important waterway for navigation and recreation. It is also a tributary of the Pearl River, which flows into the Pacific Ocean. The Canal is managed by the Honolulu Department of Water Supply and the State of Hawaii Department of Health. The Canal is subject to regulations and permits that are enforced by the state and federal government. The Canal is a critical part of the water supply system for the city of Honolulu and is essential for the health and well-being of its residents.
There are five native Daphnia (shrimp) species in the streams. They spawn in the estuaries and the larvae live in the creek, then make their way back to the stream.

vTerry Hildebrandt - (DFP)

BMPs during construction:
Must use geobrailing materials; matting stabilizes the soil until vegetation takes hold. Everyone must be aware of all the areas that could cause contamination of the Canal and Streams.

BMP:
Promote Greenways along the Streams. Using Greenways would promote public awareness and desire to keep the streams and surrounding areas clean.

vLesky Morlet - (DFP)

By planting along the Canal and Streams, you are planting ownership. The users, neighbors, especially areas that need Canal will benefit. The community must become involved. This is the solution.

BMPs:
The public needs to be involved. The government can facilitate, provide expertise, but there isn't enough money in government to handle the entire problem. You must start with education, and you should start with the young. Kids are more enthusiastic and take the message and want to learn and help out. Their actions affect their parents, who have been less likely to change their ways. Kids put pressure on their parents to stop littering. You can and will stop people from littering. Continue with the Adopt-A-Park program with the City. This will lead to better awareness among the public.

vGerald Keicho - (DOA)

The majority of pesticide contamination is from termiteicides. There are different types of termite control processes involved. Chemical barriers are pumped into the ground and bind to the soil. The soil then washes into the Canal and Streams.

BMPs to prevent this type of problem:
1. Control runoff.
2. Monitor, or better yet, instill Integrated Pest Management (IPM). IPM would require economic/research threshold to apply IPM.
3. Need to modify construction, design and landscaping practices to help control runoff.
4. Use alternative termite products such as barrier termite barriers in conjunction with treated wood, or use termite bait systems.

Question: Are barrier termite barriers mandatory?

Answer: No, not yet.

Question: What is the application rate for the chemicals?

Answer: There is no set rate. Only spot treatments are done if needed. Some studies show a 5-year rate.

Question: What was the wood treatment controversy?

Answer: Some chemicals didn't penetrate wood, the other was that the chemical did penetrate the wood but wasn't effective.

vVehicle Pollution:
Gerald Talayesuy - (PAPW)

Vehicle pollution includes: gas fumes, oil, batteries.

Graph:
1. Need to clean streets, storm drains and streams, thereby eliminating pollution into the Canal and Streams.
2. Must have public education, such as workshops to provide information on how people affect the Canal and Streams. Combo car washes were discussed as a source of pollution.
3. We must explore alternative sources of fuel.

vDeeping City Programs:
Alex Ho - (DFP)

There are various ongoing City programs to help prevent and clean litter. Education is key to preventing litter. Everyone must understand the problems associated with littering. There must be Community participation in these efforts. Various programs that are in effect and have been effective are: the stretching of storm drains, Adopt-a-Stream program, Adopt-A-Highway program (State), Adopt-A-Park program, and installing floating booms to catch debris.

Question: What kind of litter have you been finding?

Answer: All kinds.

Question: Any information on the extent of pollution that comes from drivers, learned or unlocked companies?

Answer: They are monitoring catch basins near industrial and residential areas. Operation Kubus collected a lot of the bulk garbage that had been lying around the City.

Question: Why can Combo use car washes now? They were stopped for a while.

Answer: Interpretation of the law changed. Combo are now included in the single family residence category (per EPA).

vVegetation and Sediment:
Khalli Spencer - (UR)

Local pollution (metals) stay bound to soil. This transports the pollutants to the Canal.

BMP: Prevent solids from going into e-waters.

Metal content of streams is progressively worse as you go down the streams. Metals are still leaching out of the streams. Leach is coming from older homes with lead paint, cars, busy roads (old solvent gas).

BMP: Control what is already out there and prevent future contamination. For example: Erosion control around older homes and heavier used roads through vegetation.
Vegetation for Buffers and Erosion Control, Structural Erosion Control, Stream and Trail Restoration and Erosion Control

Vegetation - Lisa Fernøe (WI Dept. of Agonomy & Soil Science)

There are various plants available to use as vegetation buffers and for erosion control. Generally people use rock/cone/banks or vegetation or a combination of both. Why would you use vegetation? It would protect streambanks. It provides habitat for aquatic life, and acts as a buffer for runoff into streams. Forested buffers are preferred, however what is below the trees is more important than the trees. You need to be aware that there is still erosion in the forest.

BMP:
Try to grade stream systems and incorporate vegetation. You could create terraces, use fascine systems, install brush layers that build up bank, use gabions with vegetation, bioengineering systems, gravel construction.

There are various and numerous types of vegetation available with good root systems. Question: Would bamboo work? Answer: No, and it use would be controversial.

Comment: You need to have cooperation with help with establishing system and maintaining the system.

Vegetation - Bob Hirano - (Lyman Arboriculture)

Sedimentation occurs during heavy rainfall, landslides contribute the most into the streams. The average month the stream runs clear. Big cyclones to erosion are the tule and gpi, who depriate the vegetation. There is very little native plant life left in Manoa valley.

Question: Have you seen many changes over the past years? Answer: Insects. Made big push to re-establish native plants but they are difficult to grow in areas that have been taken over by exotics.

Question: How much stream land is under your control? Answer: Little more than 1/2 mile.

Question: Do you have bank problems? Answer: Not too many bank problems - new vegetation grows quickly.

Structural Erosion Control - Cleve Smith - (HRCB)

There is a need to start focusing on urban houses in this area. There are various examples of construction maintenance problems in the area. You could reconstruct concrete stream beds to change the velocity of the water.

BMP:
Building Inspectors should get out to the site more often and check for soil erosion and require changes if needed. Building permits should be modified to include soil protection.

Question: What proportion of sediment comes from headlands vs. lowerlands? Answer: Will always have problem because rocks are soft in Hawaii. Not much time has gone by in the time line of the Earth.

BMPs:
1. We need inter-governmental community cooperation to have one purpose and everyone must buy into the process. We must educate individuals so they understand what needs to be done to help solve and prevent erosion. This would be a long term solution.
2. There should be special BMPs for parking lots.

Comment: new subdivisions in valleys only increase the erosion and flooding (roads and drainage).

Lee Ann Enfield - Private sector supplier of erosion control products (i.e. gabions, fabric, mesh).

Stream and Trail Restoration - Brian Schulz - (Youth for Environmental Service (YES))
He visits schools to talk about watersheds and their affect on the environment.

BMPs:
1. YES has adopted Manoa Valley Trail and assisted in providing erosion control measures. (replanting, keeping trails clear and clean). Their organization gets the kids involved and they are more willing to help and learn about the environment. They also remove debris from the Stream.

2. It is very important to get the community involved. You can generate a community ethic. Find ways to get community involved in activities that would have an immediate impact on the area, thereby generating a specific interest in that area.

3. YES has been involved in stenciling the storm drains. It's easy to get kids out there to do it. The stenciling has generated a lot of TV coverage and therefore more awareness about dumping trash into the drains.

4. You need to understand that kids affect the adults. Their actions can help change adult behavior.

5. Trail users and the community must be educated so they understand how their actions affect the environment. Usually if you explain the problems to people, they are very receptive.

Question: What kind of trash have you been picking up?
Answer: Old household items mostly. Picking up trash has positive effect, because when an area looks cleaner with less trash, less trash will be dumped in that area.

Question: Would it help to have transfer station for bulky trash?
Answer: The City already provides a bulk pick up service. Maybe the answer would be to get that information out to the public.

Comment: It could be that it's the commercial quantity dumping that is the problem.

Erosion Control - Troy _______
BMP: Businesses who provide erosion control measures need to get their product information out to the public.

When thinking about implementing erosion control, there are certain erosion control factors to consider:
- Soil erosion affects the quality of irrigation water.
- Soil erosion can cause water quality problems.
- Soil erosion can affect the aesthetics of the landscape.
- Soil erosion can cause increased maintenance costs.
- Soil erosion can cause increased liability.
- Soil erosion can cause increased costs for fertilization and pesticides.
- Soil erosion can cause increased costs for irrigation systems.
- Soil erosion can cause increased costs for landscaping and hardscaping.

Topic BMPs: Flood Impacts, Dredging and Storm Drain Systems

vStorm Drain Systems - Alex Wong (DOH)
Permits are needed to assure industrial companies comply with regulations.
Try to control/restore pollutants from entering drainag. Try to eliminate discharge into the drain system. Need to collect samples to test for contamination.

BMP:
1. You must have a permit to discharge into the storm drain system. Industrial activity must have a permit to discharge into storm drain system. Need to emphasize Source Control. Stop pollution at the source and eliminate the need for clean up.
2. Construction sites must have permits that state the site specific controls. These BMPs must be implemented before the construction starts. DOH doesn’t dictate which BMP to use, as long as they are using them. The Contractor picks the BMP type that is appropriate to the site.

Question: Are there BMPs that can work for auto pollution coming in from the City streets? Answer: The streets must be kept clean, storm drains must be flushed, public must keep their cars in good repair and clean. Clean up the catch basins.

vCity of Hilo - Dennis Takayasu (DPW)
(Questions are taken directly from the agenda)

Question: Can we expect runoff before it reaches the drains? Answer: Yes. Built up areas are more difficult. New developments are easier because erosion control measures can be built in from the start. All runoff can be directed into planted areas.

Question: Can we filter the runoff? Answer: Yes, by running the runoff through planted areas.

Question: How do we approach the massive complexity of the storm drainage system to improve water quality? Answer: Prevent pollutants from entering systems. How? By using the various methods discussed today.

Question: What is the design?

Answer: They don’t have one yet.

vBarry Hill - (USGS)
Barry described the USGS activities:
Stream flow record stations. Shame flow but not quality.
Great if gauge (I’m not sure I heard it correctly).
They are involved in talking with the DOW regarding water discharge and sediment.
The HWOAQP (Water Quality Assessment Program) will be implemented and will then be involved with the Canal.

vRichard Suzuki - (DPW, Drainage)
Flood Impacts:
1. Try to get rid of the drainage.
2. The Basin has many flood zones and flood ways.
3. Island wide problem, not just Canal and Streams.
4. They are working on drainage standards, they are working with NIH/DOE.
5. The velocity of the water causes a lot of sedimentation. Sedimentation comes from construction zone lands.
6. Oiling of the dredged material will be very difficult. The cost will be very high.
7. Golf courses can help remove pollutants and help prevent runoff and erosion.

Question: What is flood level in Waiakea? Answer: 2 to 3 feet.
Question: Was 1958 most recent big event in the Canal and Waiwai area? Answer: Not quite. The there has been isolated major storms instead. Hawaii Kel in late 60’s, recent flooding in Waialua. Question: Storm maintenance. Does City manage privately owned streams? Answer: City does help if danger exists. Recent litigation shows that City does have obligation to maintain streams even if they are privately owned. Question: Would catch basins help? Answer: Yes, but very expensive.

Comment: Flood waters contain contaminants, the flood channels are undersized.
Comment: We need to look at recent storms, there has been a lot of flooding. Hilo waters flood into Waiakea wa flood into Waikiki.

vtakeyama - (DWR)
Dredging affects on organisms.

There isn’t much information available on this subject. He believes that the organisms will recover quite quickly. If necessary, you could reseed the population from other streams. He wanted to be clear that the benefits of dredging far outweigh the effects on the organisms.
C  Water Quality Standards in the Ala Wai Canal Watershed
Gordon Smith, Department of Health, Environmental Planning Office
Components of Water Quality Standards

* Designated uses of waterbodies — management goals / public policy.
* Water quality criteria to support uses — technical / scientific.
  ✓ Basic criteria → narrative.
  ✓ Specific criteria → numeric values.
Examples – Designated Uses and Criteria:

* Designated use: recreation in or on water (management goal).
* Water quality criteria to support use:
  ✓ Narrative: "...waters shall be free from floating debris, oil, scum..."
  ✓ Specific: "< 200 colonies/100 ml fecal coliforms"

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<thead>
<tr>
<th>Inland Waters of Hawai‘i</th>
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<tbody>
<tr>
<td>Water types</td>
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<tr>
<td>Fresh waters (≤0.5 ppt)</td>
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<tr>
<td>* Streams</td>
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<tr>
<td>* Flowing springs and seeps</td>
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<tr>
<td>* Ditches and flumes</td>
</tr>
<tr>
<td>Brackish or saline waters (&gt;0.5 ppt)</td>
</tr>
<tr>
<td>* Anchialine pools</td>
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</tbody>
</table>
DESIGNATED USES FOR INLAND WATERS OF HAWAII

★ CLASS 1: PRISTINE-PRESERVATION / NO WASTE DISCHARGE ALLOWED

✓ CLASS 1a: Non-consumptive
  - scientific and educational purposes
  - baseline references
  - breeding stock
  - compatible recreation
  - aesthetic enjoyment

✓ CLASS 1b: Limited-consumptive
  - domestic (drinking) water supplies
  - food processing
  - support and propagation of aquatic life
  - compatible recreation
  - aesthetic enjoyment

★ CLASS 2: EXPLOITATIVE CONSUMPTIVE / DISCHARGE ALLOWED

- recreation (including bathing and swimming)
- agricultural and industrial water supply
- shipping and navigation
- protection and propagation of aquatic life

DOH Water Quality Management Programs Ala Wai Canal Watershed

Tools for BMP Development
Methods to Measure BMP Effectiveness

★ 353d List -- Water Quality Limited Waters: consistently exceed WQS.

✓ Ala Wai Harbor, Ala Wai Canal, Manoa Stream, Palolo Stream included in current revision.

★ Total Maximum Daily Load -- Numerical estimate of WQS exceedance.

✓ Calculated for nutrients in the Ala Wai Canal (with info on sediment load).

✓ 42.7 kg/day excess nitrogen, 22.4 kg/day excess phosphorous.

✓ Guidelines for reduction of nutrient input.

★ 355b Monitoring -- Water Quality Report (Clean Water Branch Monitoring Section)

✓ Watershed-based water quality monitoring in Ala Wai watershed.
D  Criteria for Handling
Drainage Discharge from Buildings and
Appurtenant Structures
Gerald Takayesu, Chief, Storm Water
Branch
Department of Public Works
City & County of Honolulu
ALL Engineers and Architects
June 19, 1995
Page 3

regulations. NPDES permit discharges and certain nonstorm water discharges that are not a source of pollutants may be discharged into the HSA without an NPDES permit.

The following classes of non-storm water may be discharged into the municipal separate storm sewer systems without an NPDES permit, provided the discharge is not a source of pollutants: landscape irrigation and irrigation water, exclusive of runoff from commercial agriculture; foundation and flooding drain, not including drainage from新建开发able activities; water from closed space pumps, including drainag from buildings with basement; and crawl space pumps used for utility connections to Kemper utility easements and other maintenance and operation administrative facilities; flows from riparian habitats and wetlands; air conditioning condenser; storm water; lawn watering; individual residential car washing; decanting/evaporating pool water; street wash water; fire hydrant flushing and discharges from portable water sources.

NPDES permit discharges include but are not limited to: storm water wastewater with industrial facilities; storm water associated with construction activities; treated groundwater from lining underground storage tank remediation sites; rain-through non-concurrent cooling water, 1 mg/l or less; hydrogenic water, and construction dumpsters. Non-storm water discharge and NPDES permit discharges into the HSA require an effluent discharge permit from the Storm Water Quality Section, Division of Engineering, DPW. Call 327-6104 for more information.

General guidelines to effect as of this date for handling discharge from buildings and

This superseded our memorandum, No. 1-94, dated February 8, 1994.

By regulation (40 CFR Part 122, Subpart E) effective November 16, 1990, large and medium municipal separate storm sewer systems are required to have a National Pollutant Discharge Elimination System (NPDES) permit for storm water discharges. The regulations implement Section 402(c)(5) of the Clean Water Act (CWA) which includes a requirement to effectively prohibit non-storm water discharges into the storm sewer.

On August 8, 1991, the Department of Health (DOH) issued NPDES Permit No. H0021123 to DPW, effective September 7, 1991, for the City and County municipal separate storm sewer systems. The permit requires DPW to effectively prohibit non-storm water discharges through the storm sewer systems into waterways except runoff from its lighting activities which is exempt by Federal

This memorandum is to: ALL ENGINEERS AND ARCHITECTS
KENNETH E. SPARGO, DIRECTOR AND CHIEF ENGINEER DEPARTMENT OF PUBLIC WORKS
CECIL L. FUKUOKA, DEPUTY DIRECTOR AND BUILDING SUPERINTENDENT
KERRY E. MILSAN, DEPUTY DIRECTOR
HAROLD H. TAKAYAMA, DIRECTOR DEPARTMENT OF WASTEWATER MANAGEMENT

RE: CRITERIA FOR HANDLING DISCHARGE FROM BUILDINGS AND ASSOCIATED STRUCTURES.

Laws: Chapter H60, Hawaii Revised Statutes, "Water Pollution" Chapter 14, Article 1 through 11, Hawaii Revised Ordinance of Honolulu 1995, Sewer Ordinance Chapter 14, Article 12, Revised Ordinance of Honolulu 1995, "Drainage, Flood and Pollution Control."

This memorandum, No. 1-94, dated February 8, 1994.

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All Engineers and Architects
June 19, 1995
Page 3
The following table indicates types of discharges and the system in which connections are generally permitted:

<table>
<thead>
<tr>
<th>Discharge</th>
<th>Sump Drain</th>
<th>Storm Drain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Indoor Commercial and Condominium Club and Equipment Wash Water with Preheatwash</td>
<td>Yes¹</td>
<td>No</td>
</tr>
<tr>
<td>2. Outdoor Commercial and Condominium Club and Equipment Wash Water without Food with Preheating</td>
<td>Yes¹</td>
<td>No</td>
</tr>
<tr>
<td>3. Drains for Storm Water Runoff and Roof Drains</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>4. Floor Drains for General Parking Area, Washroom and Washdown Area</td>
<td>Yes²</td>
<td>No²</td>
</tr>
<tr>
<td>5. Floor Pumps for Boilers, Hot Water Generators, Compressors, and Valve Drains or Storm Blowoff Separators, Pressure, Ice Machiné</td>
<td>Yes²</td>
<td>No²</td>
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<tr>
<td>6. Swimming Pool Water, Jacuzzi and Spa Drains</td>
<td>No²</td>
<td>Yes²</td>
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<tr>
<td>7. Swimming Pool Water, Jacuzzi and Spa where there are no Storm Drains</td>
<td>No²</td>
<td>Yes²</td>
</tr>
<tr>
<td>8. Swimming Pool, Jacuzzi and Spa Backwash Water</td>
<td>Yes³</td>
<td>No³</td>
</tr>
<tr>
<td>9. Indoor Fish Pond Drains and Backwash</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>10. Outdoor Fish Pond Drains and Backwash</td>
<td>Yes³</td>
<td>No³</td>
</tr>
<tr>
<td>11. Sump Drains for Unventilated Ground Water Seeps</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>12. Air Conditioning Cooling Tower Water</td>
<td>Yes²</td>
<td>No²</td>
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<tr>
<td>13. Air Conditioning Overthrough Condenser Water</td>
<td>Yes²</td>
<td>No²</td>
</tr>
<tr>
<td>14. Air Conditioning Cooling Coil Condensate</td>
<td>Yes²</td>
<td>No²</td>
</tr>
<tr>
<td>15. Indoor Decorative Features Including Jacuzzis</td>
<td>Yes²</td>
<td>No²</td>
</tr>
<tr>
<td>16. Outdoor Decorative Features and Fountains including Jacuzzis</td>
<td>Yes²</td>
<td>No²</td>
</tr>
<tr>
<td>17. Equipment Cooling Water</td>
<td>Yes²</td>
<td>No²</td>
</tr>
<tr>
<td>18. Elevator Scarp</td>
<td>Yes²</td>
<td>No²</td>
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</tbody>
</table>

**NOTE:** For discharge into sanitary sewers from Items 4, 5, 7, 8, 9, 10, 13, 14, 15, 16, and 17, the discharge rate should not exceed 300 gallons per minute (gpm).
BMP: VEHICLE LEAK AND SPILL CONTROL

DESCRIPTION

Prevent or reduce the discharge of pollutants as waste water from vehicle leaks and spills. Minimize the distance spills go, using spill control devices and cleaning up spills, properly disposing of spill material, and notifying employees.

This BMP applies to vehicles and equipment involved in the transport of materials, chemicals, or waste. It does not apply to spills at an off-road fueling station.

APPROACH

Monitor oil leaks and spill fluids. The key is to reduce the frequency and severity of leaks and spills, and when they do occur, to prevent or reduce their detrimental impacts.

- Perform fluid renewal and changes inside or outside control on paved surfaces.
- Properly store hazardous aquatic or water.
- Have spill cleanup supplies ready, available.
- Clean up spills and leaks immediately.
- Use the spill response.
- For a spill response, refer to disposal instructions for specific materials, see Table 4.1: SC40.

MODEL SPILL RESPONSE

Treated Commercial

- Bagging
- Maintenance
- Mortar Analysis
- Roadside Materials
- Pesticides (as chemicals)
- Engine Oils
- Tires
- Gasoline
- Diesel
- Oil

For a spill response, refer to disposal instructions for specific materials, see Table 4.1: SC40.

PUBLIC EDUCATION AND PARTICIPATION

- Spread the good news about responsible vehicle owners and maintain their vehicles.

LIMITATIONS

- The largest spills, a vehicle with complex component and intimate waste may not be necessary.

Municipal Handbook

March, 1993

Additional Information — Vehicle Leak and Spill Control

Major spills as required by other public agencies are generally handled by the owner or operator from local fire departments or environmental health agencies. The owners handle smaller spills by themselves or minor spills at vehicle maintenance shops (such as municipal service centers or employee-owned vehicles).

C-18/1993

Spill cleanup materials and systems should be stored in a secure area and protected from vandalism. If possible, site spill cleanup materials where they will be readily accessible.

- Train employees in spill prevention and clean up.

Spill Prevention and Control

- Clean up leaks and spills as soon as possible.
- On paved surfaces, grow-up spills with soaks or cover with sludge. Use a rag for quick spills, a drop cloth for general cleanup, and a water source for larger spills. If the applied material is haphazard, then the soil cleanup standards are also haphazard and may be either a certifiedonly (soil) or disposal of haphazard water. Never boil down or keep dry any material spills. Evaporate the cleanup will depend on property.

C-18/1993

- Require spills to be reported to the relevant state or local enforcement agency.
- Implement regulations despite the fact that any spill or waste water could be an additional requirement to be expected by the enforcement agency (SC40 or SC41).

Use the following information related to specific activities:

Vehicle Leak and Spill Control

- Perform all vehicle maintenance or cleaning inside or outside control on paved surfaces or waste water.
- Require proper maintenance and equipment, including delivery vehicles, and employees and subcontractor vehicles.
- Avoid hauling all kinds of materials, including transport vehicles of waste equipment.
- Always use secondary containment, such as a drop cloth or drop cloth, to catch spills or leaks when moving or changing fluids.
- Immediately clean all spills from exposed surfaces.
- Store waste material or damaged equipment under cover.
- Place drop parts or replace-spare parts under heavy equipment when not in use.
- Use absorbent materials to oil spills makes that they are drained off the floor, long for the transportation materials properly and dispose of properly.
- Properly manage and dispose of the proper waste or recycling businesses. Don't let full oil pans or other empty containers lie around.
- Oil filters disposed of in trash or dissolved can kill all aquatic systems and water. Place the oil filter in the solid waste, not in the oil filters. Oil filters can be recycled. Ask your oil supplier or recycler when recycling oil filters.
- Some critical behavior is to keep oiled with all the contact surfaces, even if you think all the oil has drained off. If you drop a bottle, think it is full and is broken, put it onto the contamination area until you are sure it is not leaking.

Municipal Handbook

March, 1993

March, 1993
Additional Information: Vehicle Leak and Split Control

Vehicle and Driveway Parking
- Design the building area to prevent the runoff of storm water and the result of splits.
- Ensure that the area is properly designed.
- Allow for the complete avoidance of driveway leakage by installing a seal.
- Prevent the access to storm water runoff.
- Ensure that the road system is properly designed and planned.
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E  Suggested BMPs for Litter and Debris Problems, Alex Ho, Environmental Engineer, DPW, C&C
Litter and Debris

Every time, after a heavy rain or an intensive shower, one common phenomenon in the Ala Wai Canal is that large amount of debris and litter is floating either in the canal or lying on the canal's path. Litter is primarily composed of trash, cigarette ends, food and drink containers, and bottle caps. The cause of the large amount of debris and litter is primarily the result of natural processes. Some of the litter is brought into the canal from the city's streets and alleys, while other litter is transported from distant areas to the canal by the wind or floodwater. In addition, many people throw their trash into the canal, either intentionally or unintentionally. This litter not only pollutes the environment, but also poses a hazard to wildlife and humans alike. The most effective way to control and reduce litter and debris dumping is through public education and public participation.

Currently, the City has the following programs that would control and reduce litter/debris problems:

1. Storm Drain Stenciling:
   With a joint effort between the City and the State Department of Health, a storm drain stenciling program was established in early 1995. The volunteers who consist of citizen groups, such as the Ala Wai Canal Association, are responsible for stenciling the City of Honolulu with a message of "No dumping, go to can". Thus far, more than 5,000 storm drains have been stenciled and the program has been expanded to include military housing areas.

2. Adopt-A-Stream Program:
   In September 1996, the City developed an "Adopt-A-Stream" program with the purpose to promote and enhance the public's environmental awareness and understanding related to nonpoint source pollution control in order to preserve our natural resources and improve the quality of our water. The program provides an opportunity for interested community groups to take ownership of their streams and to keep the stream free from litter and other pollutants. Each group will have a sign displaying the organization's name posted at the adopted section of the stream. The City will provide supplies and materials for stream litter cleanup and subsequent garbage bag pick-up. So far, 96 community groups have participated in this program.
F Gabion Streambank Protection
Project Note
Richard Frey
Engineering Solutions, Inc, Aiea.
24 February 1997

TO: Ala Wai Canal Watershed Water Quality Improvement Project
    1314 South King Street, Suite 951
    Honolulu, Hawaii 96814-1354
    FAX 599-8330

ATTN: Mr. Eugene P. Dashiell, Coordinator

FROM: Richard Frey

RE: BMP Workshop

TOTAL NO. OF PAGES TRANSMITTED (including this sheet) 1

COMMENTS:

Thank you for the invitation to the workshop. Unfortunately we are moving our office on that day and I will not be able to attend. If possible, I would like to receive the written conference proceedings. Our new office location is:

Engineering Solutions, Inc.
213 Pearlridge Center, Uptown
98-1005 Moanalua Road
Aiea, Hawaii 96701

telephone 488-0477
facsimile 488-3776

Our gabion streambank protection project for the Manoa Village Homeowner's Association on Manoa Stream has received approvals from everyone except DLNR Land Division. We hope to receive their approval soon. If construction goes as planned, it should be finished by late summer. I will let you know when the project is finished, so you can take a look at it.

END
G  Contaminants:
Sources, problems, typical BMPs
Eugene Akazawa, Clean Water Branch
DOH
The subject of this panel session refers to various contaminants as shown on your agenda. It includes bacteria, the subject of my brief talk. But I would like to focus on the question: “What have we learned in all these years by using indicator bacteria as a basis for determining the safety of our recreational waters?”

1. Let me begin by saying that no water quality standard will guarantee complete safety for everyone. I think this is a very fair statement to make, and perhaps everyone here agrees to this. What is risky for one person may be safe for another. But nevertheless, an appropriate standard for safe swimming should one that will ensure the safety of everyone using the water.

2. The density of the indicator bacteria that we use, enterococci, is always at a much higher level during and immediately after a heavy rainfall. Our heaviest rainfall period begins in November and ends around April... these are same months that show the highest density of bacteria in our waters.

3. By the last statement not only can we conclude that bacteria densities are higher during the wet season, but that the sources of bacteria also can be and is attributed to nonpoint pollution.

4. We also know better now that the indicator bacteria, enterococci, are in fact found in the soil, vegetation, birds, and other animals as well. Dr. Roger Fujita and his co-workers at the University of Hawaii have discovered enterococci in Hawaii and other tropical islands that are naturally occurring in the environment.

5. This being the case, the existing recreational water quality standards and the tests we do will not actually tell us the acceptable level of risk.

As we improve the Ala Wai Canal in various other ways, aesthetically or structurally, there will always be a lingering concern among the users of the canal. Risk assessment is a difficult task... and as I have mentioned earlier, what is risky for one person may be safe for another. But most importantly is how do we deal with the management of public health risk? Briefly, the following are some of the important areas of risk management, that we as public health officials must concentrate on:

- Public health risks associated with sewage discharges. There will always be breaks in the sewer lines. The question is how do we reduce the threat to public health?
- Risks associated with handling and disposal of toxic materials. What are the risks associated with consumption of contaminated fish or shellfish?
- Reducing public health risks through education among critical target groups. Are users...
of the water aware of potential dangers? What precautions can they take to reduce the chance of getting infected by diseases?

> Prioritizing and funding research needs on public health safety of recreational waters and among target groups. Should we be doing more in this area?

> And last but not least, for the Ala Wai Canal, find out the answer to the question: “How safe is the canal for water recreation?”

In closing I would like to say this. Under the water quality standard for streams in Hawaii the safe level is set at 100 fecal coliform units. At this level, the amount of fecal bacteria is the same as if it dump one gallon of untreated sewage into a 10,000 gallon swimming pool that is not chlorinated. Would you consider swimming in it?

Notes:
The Department of Health has established water quality standards for marine recreational waters based on the geometric mean density of enterococci bacteria at 7 CFU. What is the acceptable level of risk at this level? At this level the expected rate of gastrointestinal illness is one per 100 swimmers. The EPA criterion, however, is set at 35 CFU and the expected rate of swimming-associated gastrointestinal illnesses are two per 100 swimmers. We might say that the Hawaii standards are twice as strict as the EPA guideline.
Streambank Vegetation BMPs, and Vegetation Types Suitable for the Ala Wai Canal Watershed, Lisa Farrantinos, Watershed Consultant.
What is the role of streambank vegetation?

- Protects streambanks
  - Removes water and slowly releases it during dry periods
  - Improves stability
  - Slows the velocity of the water
- Provides habitat for aquatic life
  - Creates ripples and eddies, more oxygen
  - Leaves for food
  - Shade lowers water temperatures, increases oxygen
- Buffers streams from runoff pollution
  - Helps suspended materials settle
  - Breaks down pollutants through the action of soil and root microorganisms
Why are forested buffers preferred?

- Organic layer (duff) that traps and filters
- Deep and dispersed root systems that help filter groundwater

Why is there erosion from forests?

- When rain drops leave the trees
- Lack of groundcovers
- Lack of duff layer
- Reduced organic matter in soils
- Type of root systems
- Gully formation
Stabilize Slope by Creating Terraced Banks

Fascine Installation

1. Place fascine at top
2. Add fascine along slope
3. Repeat
4. Cover top fascine with soil

Temporary Fencing

Gates can be placed on or off fencing
Either side facing
Low vertical walls
Seashore paspalum  *Paspalum vaginatum*

‘Aki‘aki  *Sporobolus virginicus*

Nanea  *Vigna marina*

Pohuehue  *Ipomea per-caprae*

Water hyssop  *Bacopa monnieri*

Nehe  *Lipochaeta integrifolia*

‘Ilma papa  *Sida fallax*

Pohinahina  *Vitex rotundifolia*

‘Akia  *Wikstroemia woa-arsi*

Pa‘u o Hi‘iaka  *Jacquemontia ovalifolia*

Naupaka  *Scaevola sericea*

Milo  *Theophrasta populnea*

Hau  *Hibiscus tiliaceus*

Hala  *Pandanus tectorius*

Ulala  *Sweet potato*

‘A‘ali‘i

Kuku‘i

‘Ulei

‘Olona

Kolomona

Manele

Wiliwili

Alahe‘e

Ti
Kukui
'Ohi'a 'ai
Hala
Koa
'Ohi'a
Lama
Loulou
'Oha wai
'Ie'i'e
Hapu'u
Koki'o
Mamaki
Olapa
Kupakupa

'Ulei
'Awapuhi
'Uluhe
Palapalai
'Ala'ala wai nui
Water Plants

*Hyacinth  *Eichhornia crassipes  *Monochoria vaginalis

*Lemna  *Spirodella polyrrhiza  *Wolfia columbiana  *Lemma purpurea

*Water lettuce  *Pistia stratiotes

*Water fern  *Azolla filiculoides

Taros  *Colocasia  *Alocasia  *Cyrtosperma

Aquatic fern  *Ceratopteris thalictroides

Neke fern  *Cyclosorus interruptus

Sedges  *Cyperaceae - numerous


*Danger-channel cloggers

NOT

Java Plum  Koa Hao  Christmasberry  Banyans  Australian Tree Fern  Guava and Strawberry guava  Kahili ginger  Fountain grass  Cane Tibouchina  Clidemia  Melastomes
Maybe Not?
Exotic grasses
Hau

Paul Weisich's Pearl Harbor Road Cut Study
Recommended:
'Ulei
'Akia
'Ilie'e (plumbaga)
A'ali'i
Naupaka
Wiliwili

ESTABLISHMENT
MAINTENANCE

Waialua, O'ahu

Stargrass  *Cynodon plectostachyum*
Contribution of Stream Channel Erosion to Sediment Yield from an Urbanizing Watershed

Submitted by: June Harrigan, Ph.D., DOH.
Stream channel erosion has long been suspected as the major contributor to long-term sediment yield from urbanizing watersheds. For San Diego Creek in southern California, measurements from 1955 to 1993 showed that stream channel erosion furnished 10% of the megayear per year of sediment, or about two-thirds of the total sediment yield. Thus, because channel erosion can be a major source of sediment yield from urbanizing areas, channel stabilization should be a priority in managing sediment yield.

Stream channel erosion can be the major source of sediment in urbanizing watersheds, with channel erosion, bank erosion, and bank wash contributing significantly. For San Diego Creek, which discharges into the Pacific Ocean, a stream channel erosion contribution of 10% was observed. This erosion is significant because it can reduce the amount of sediment available for downstream processes, such as sediment transport and deposition.

In general, stream channel erosion is a complex process influenced by factors such as channel morphology, flow characteristics, and land use. Understanding the mechanisms of channel erosion is crucial for effective channel management and erosion control. Further research is needed to better quantify the role of channel erosion in sediment yield and to develop effective strategies for its mitigation.

Stream channel erosion is a significant contributor to sediment yield in urbanizing watersheds, and channel stabilization is essential for effective sediment management.
Fig. 1. San Diego Creek, showing the successional stream channel network and the expansion of urban land, 1830-90. Fine-grained channels and channels lacking upstream were not included in the study. The cross-sectional channel profiles shown are those remaining in 1990. Sediment yield is that measured at the gauging site, as accretion in the trunk stream and sediment traps. A and B indicate the profiles shown in Fig. 3.

Fig. 2. Example of stream channel erosion in Hole Canyon Wash, looking southwest at the confluence with Racemaria Canyon Wash (Fig. 3). A person stands at approximately the same location in both photographs. Note the scar of the washout bank to the right. Arrow mark the location of surveyed profiles in 1981 and 1991 (Fig. 3).

Fig. 3. Surveyed stream channel profiles in Hole Canyon Wash (profile A, 1981 and 1991; Fig. 2). The rate of erosion at this profile was 29.77 m3 year⁻¹ per meter of channel. At a bulk-specific gravity of 1.44, this would be 0.075 Mg m⁻² year⁻¹. A total erosion rate that was about 15% less than the decadal mean for this type of channel. (B) Estimation of erosion at Hole Canyon Wash profile B, directly downstream from an urbanizing area during the wet years of 1990-1991. The rate of erosion was about 20.3 ± 1.9 m³ year⁻¹ or about 0.057 Mg m⁻² year⁻¹ per meter of channel. This result has since been verified. See Fig. 4 for locations.

mg year⁻¹ and suspended sediment yield at the station was 77 ± 105 Mg year⁻¹, constituting a total sediment sink and flux of 120 ± 105 Mg year⁻¹ (see sediment budget, Fig. 1). Thus, channel erosion accounted for about two-thirds of the measured sediment yield from San Diego Creek. Average erosion rates show few signs of declining, and new developments may locally accelerate channel erosion (Fig. 3B). Hence, amelioration of channel erosion is an appropriate management strategy for sediment control, but little had been done by 1993.

The usually perceived problem with stream channel erosion is that it has deleterious downstream effects in reservoirs, lakes, and estuaries. However, the erosional process itself is also problematic because channel enlargement is often lateral, thus removing substantial areas of valuable urban land damaging parkland, bridges, and other infrastructure and making channels unsafe (2, 4) (Fig. 3). The process of sediment loss in urbanizing basins is analogous to the formation of arroyos that occurred in the Southwest in the late 19th and early 20th centuries (2, 4). However, rather than graying or cli-
Adatom Pairing Structures for Ge on Si(100): The Initial Stage of Island Formation

X. R. Qin and M. G. Lagally

With the aid of scanning tunneling microscopy, it is shown that germanium atoms adsorbed on the Si(100) surface of silicon near room temperature form extraordinary structures that are tilted from the substrate dimer bond direction and consist of two-atom units arranged in adjacent substrate troughs. These units are distinctly different from surface dimers. They may be viewed as the link missing in our understanding of the elementary processes in epitaxial film growth: the step between monolayer adsorption and the initial formation of two-dimensional growth islands.

Because of its importance, micro-electronics and its unique properties, the Si(100) surface of silicon has been intensively investigated. Driven by the capability of the scanning tunneling microscope (STM) to view this surface easily with atomic resolution, Si(100) in particular has been used as a model to understand the atomic-scale structures of the surface. For example, (1) for both Si and Ge deposition, initial stages of growth are observed to produce many stable adsorbed dimers called ad-dimers, that is, two-atom clusters that clearly remain bound to each other for extended periods, as well as rows of many such ad-dimers (called islands) (2, 3). Following classical radiationchemistry, in which growth occurs by the addition of atoms to a "critical nucleus" (N), it was proposed that Si or Ge molecules deposited on the Si(100) surface diffuse to form ad-dimers and that the ad-dimer is the stable nucleation from which all subsequent larger growd structures (such as the ad-dimer row islands) evolve by addition of further molecules (2). Intermediate structures ("diluted ad-dimers"), in which a variable ad-dimer number in the island is present, have been postulated.

The experiments were performed on Si(100) with a high-quality surface in a UHV system in which the Si(100) surface exist as two-atom units that are distinctly different from each other. A four-atom unit in STM, which all appear to be the nucleation-grow physician.

The experiments worked performed on Si(100) with a high-quality surface in a UHV system in which the Si(100) surface exist as two-atom units that are distinctly different from each other. A four-atom unit in STM, which all appear to be the nucleation-grow physician.

The experiments worked performed on Si(100) with a high-quality surface in a UHV system in which the Si(100) surface exist as two-atom units that are distinctly different from each other. A four-atom unit in STM, which all appear to be the nucleation-grow physician.
J  Suspended Sediment Production from Forested Watersheds on Oahu, Hawaii, Submitted by U.S. Forest Service and DLNR Division of Forestry.
SUSPENDED SEDIMENT PRODUCTION FROM FORESTED WATERSHEDS ON OAHU, HAWAII

R. D. Doty, R. R. Wood, and R. A. Merritt

ABSTRACT: Suspended sediment from forested and agricultural watersheds was sampled over a four-year period on the Island of Oahu. A variety of storm conditions were sampled, giving a measure of the extreme variability in suspended sediment production. Total annual suspended sediment from all watersheds sampled ranged from 840 kg/km² to 671,000 kg/km². Normally, about 90 percent of the total suspended sediment was produced during less than 2 percent of the time. Suspended sediments concentrations rapidly increased during rising stream flow resulting from rain storms. Time to reach less than two hours is common, with a similarly rapid return to prestorm conditions. The data presented indicate the great variability of suspended sediment yields, making establishment of effective standards difficult.

(KEY TERMS: suspended sediment; forests; water quality; standards; Hawaii; storm flow.)

Attempts to control flooding and sediment production on Oahu by reforestation date back to 1892 (Honolulu Board of Water Supply, 1948). Little has been reported, however, on the production of suspended sediment from forested areas in Hawaii. Neither erosion nor sediment were included in separate index entries in a bibliography of water resources in Hawaii published in 1974 (Plund and Steller, 1971). Nearly all the data available on sediment production in Hawaii to date were collected at gauging stations which sample a cross section of forest, agricultural, and urban areas. Because the forested areas generally have steep slopes and receive large amounts of rainfall, it is assumed that these areas produce high sediment yields, but confirmation has been lacking.

This report summarizes the suspended sediment records for Oahu for watersheds with two or more years of records. The data provide a measure of the variability and magnitude of sediment yields, and should help to provide a basis for establishing sediment control techniques and regulatory procedures.

The watersheds described here drain the steep slopes of the Ko'olau Mountains of Oahu (Table 1). The large watershed, Waikole, also includes the flatter agricultural layout of the central plain of Oahu (Figure 1). The forested areas of Kipapa, Kalahi, and Manamalu are primarily native ohia-kou (Metrostemon euryphyllum, Acanthox. koa). However, 40 percent of the forest covered areas of Kalahi are exotic species planted for watershed protection 60 to 70 years ago. About 50 percent of the shrub and herbaceous cover on Manamalu is a combination of pastures, 'ananas plantations, and a large golf course. The 31 percent cultivated area of Waikole is divided between pineapple and sugarcane fields which occupy the flatter areas. The forested areas generally occupy the areas of slope greater than 39 percent (Table 1).

The soils information in the table is a summary from the soil survey of Hawaii (U.S. Soil Conservation Service, 1972). Runoff and erosion hazard levels generally increase with slope steepness; thus there is potentially severe erosion in the mountainous areas if the soil is exposed to high rainfall. Stream flow conditions shown indicate the rapid rise to peak and extremely high peak flow that are characteristic of these watersheds.

METHODS

The data reported here come primarily from published records of the U.S. Geological Survey (USGS) stations equipped with automatic timing sediment samplers (Model USGS-69) at stream gauging stations. Kalahi was hand sampled by U.S. Forest Service personnel during storm runoff periods, using a D-59-64 phelium integrating sampler. A total of 250 hand samples were collected from Kalahi during the period November 1974 through September 1975. All samples were analyzed for suspended sediment concentrations at the USGS laboratory in Honolulu.

In the method used at stations maintained by the USGS, individual sample values for suspended sediment concentration were plotted directly on the stream flow hydrographs. A smooth curve was hand fitted through the points. This curve was then used to calculate the total sediment yields on a daily basis, which were reported in USGS annual reports (U.S. Geological Survey, 1973-78).

Sediment yields from Kalahi were determined by a method similar to one described by Miller (1951) and used in Hawaii by Jones, et al. (1971). Instantaneous water discharge were correlated with instantaneous suspended sediment discharges to develop a sediment transport curve. A stream flow duration
curve was then used to calculate total sediment production on an annual basis from values for the amount of time the flow was at various levels.

To compare the procedure used at Kipapa with that at Kalibi, we selected days in which samples were available from both. A water discharge/sediment discharge relation for Kipa- pa was developed based on those samples. Sample values from Kipapa and Kalibi include a range of flows from mini- mum through storm values that fall in the upper 10 percent of all flows recorded at the stream gauging stations.

**TABLE 1. Watershed Characteristics**

<table>
<thead>
<tr>
<th>Drainage Area (km²)</th>
<th>Percentage of Total Area in Class</th>
<th>Permeability</th>
<th>Runoff</th>
<th>Erosion Hazard</th>
<th>Vegetation Type and Percent of Total Area</th>
<th>Mean Annual Precipitation (mm)</th>
<th>Mean Precip. Discharge (m³/sec)</th>
<th>Average Discharge (m³/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalibi 16-2299</td>
<td>6.76</td>
<td>0-10</td>
<td>8.0</td>
<td>Moderate</td>
<td>Slow</td>
<td>3100</td>
<td>51.67</td>
<td>0.00</td>
</tr>
<tr>
<td></td>
<td>11-20</td>
<td>8.0</td>
<td>Moderate</td>
<td>Slow</td>
<td>Siltation-Riparian-15%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20-30</td>
<td>8.0</td>
<td>Moderate</td>
<td>Slow</td>
<td>Riparian-Moderate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>51.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>Riparian-Siltation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kipapa 16-2218</td>
<td>11.10</td>
<td>0-10</td>
<td>0.6</td>
<td>Moderate</td>
<td>Slow</td>
<td>4420</td>
<td>14.49</td>
<td>9.47</td>
</tr>
<tr>
<td></td>
<td>11-20</td>
<td>8.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>Siltation-Riparian-3%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21-30</td>
<td>9.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>Riparian-Siltation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>50.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>Riparian-Siltation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kauaulike 16-2330</td>
<td>118.3</td>
<td>1-990</td>
<td>46.0</td>
<td>Moderate</td>
<td>Slow</td>
<td>1780</td>
<td>3.25</td>
<td>51.10</td>
</tr>
<tr>
<td></td>
<td>11-20</td>
<td>8.0</td>
<td>Moderate</td>
<td>Slow</td>
<td>Siltation-Riparian-25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21-30</td>
<td>8.0</td>
<td>Moderate</td>
<td>Slow</td>
<td>Siltation-Riparian-25%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>47.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>Riparian-Siltation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Honapiau 16-2157</td>
<td>2.43</td>
<td>201-762</td>
<td>5.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>4950</td>
<td>17.80</td>
<td>1.10</td>
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<tr>
<td></td>
<td>&gt;30</td>
<td>95.0</td>
<td>Unclassified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kanaolani 16-2722</td>
<td>9.87</td>
<td>20-762</td>
<td>30.0</td>
<td>Moderate</td>
<td>Slow</td>
<td>2540</td>
<td>2.78</td>
<td>Not established</td>
</tr>
<tr>
<td></td>
<td>11-20</td>
<td>8.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>Riparian-Moderate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>21-30</td>
<td>8.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>Riparian-Moderate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;30</td>
<td>60.0</td>
<td>Rapid</td>
<td>Slow</td>
<td>Riparian-Moderate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kanaolani 15-764</td>
<td>3.31</td>
<td>36-764</td>
<td>5.0</td>
<td>Moderate</td>
<td>Slow</td>
<td>2540</td>
<td>16.80</td>
<td>9.74</td>
</tr>
</tbody>
</table>

1 Watershed numbers correspond to U.S. Geological Survey reference numbers.

WATER RESOURCES BULLETIN
RESULTS

The data in Table 2 summarize the suspended sediment records on Oahu for stations with records covering more than two years, for which sufficient samples were taken each year to calculate a total annual suspended sediment. Volume of sediment per year ranged from 9.7 Mg/km² to 617 Mg/km². The range of values cuts across all watersheds.

Because Kipapa Stream is a tributary to Waikele Stream, it is interesting to compare the relative suspended sediment production from these two watersheds. The watershed area of Kipapa (11.14 km²) represents 9.4 percent of the total area of Waikele (118.4 km²). During this study, Kipapa produced 27 percent of the total water yield, while producing 10 percent of the suspended sediment discharge.

In addition to total sediment yield, we should look at the distribution of the suspended sediment discharge. Generally, more than 80 percent of the annual suspended sediment discharge was produced during less than 2 percent of the time (Table 3).

Two or three storms each year usually stand out as the major contributors to the annual total suspended sediment discharge.

Stream flow conditions in this study were similar to those reported for Hawaii by others (Jones, et al., 1971; Wang, et al., 1970; Jones and Ewart, 1973; Ekern, 1976). The extremely rapid rise to peak flows resulted in corresponding high sediment yields during the rising stage and generally a more rapid drop in suspended sediment during the falling stage (Figures 2 and 3). Several storms were analyzed with similar results. A significant relationship exists between instantaneous stream flow and sediment discharge (Table 4, Figure 4). A covariance analysis comparing the different years of data from Kalahi indicated no significant difference in slope or position of the regression line for each year's data. Consequently, the pooled
data could be used to calculate average annual yield. However, better estimates of annual yields are obtained by applying the separate regression equations.

**DISCUSSION**

The suspended sediment data presented here indicate what might be expected in magnitude and timing of suspended sediment discharge from forested watersheds on Oahu. The total suspended sediment yields were found to be quite variable (Table 2). Kipapa produced a very high yield per unit area in 1974, as a result of one or two precipitation events — storms which produced high runoff rates in the Kipapa area. In 1977, stream flow was well below normal outside of the Kipapa drainage, with a corresponding low sediment yield as recorded by the Waikiele Station. A two- to threefold lower stream flow from Waikiele resulted in a tenfold reduction in sediment in 1977 and 1978. This suggests that the available flow was insufficient to flush the stream. Peak flows were equally low, a major factor in moving sediment.

Also important is the timing of the suspended sediment discharge, as it affects current consideration of alternative ways of setting State water quality standards (State of Hawaii, Department of Health, 1978). The rapid change in suspended sediment concentrations during storms and the short duration of storm events make it difficult to observe any additional “disturbance created” sediment. Such sediment may be masked by the large influx of “normal” sediment during a storm. The fact that natural variation in sediment production between drainages further complicates setting standards is evident from a comparison of the actual values and the 1978 standards (Table 3). Concentration values for some streams

---

**TABLE 2. Water Discharge and Suspended Sediment Discharge From Watersheds on Oahu, Hawaii.**

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Year</th>
<th>Annual Volume (m³x10⁶)</th>
<th>Annual Discharge (Mgyr)</th>
<th>Peak Volume (m³x10⁶)</th>
<th>Peak Discharge (Mgyr)</th>
<th>Suspended Sediment Annual Discharge (Mg/yr)</th>
<th>Mean Suspended Sediment Concentration (mg/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalihili/16-2290</td>
<td>1974</td>
<td>5.60</td>
<td>4.62</td>
<td>390.0</td>
<td>57.7</td>
<td>10</td>
<td></td>
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<tr>
<td></td>
<td>1975</td>
<td>4.00</td>
<td>3.95</td>
<td>830.0</td>
<td>123.0</td>
<td>5</td>
<td></td>
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<tr>
<td></td>
<td>1976</td>
<td>3.40</td>
<td>3.45</td>
<td>140.0</td>
<td>25.0</td>
<td>5</td>
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<tr>
<td></td>
<td>1977</td>
<td>3.20</td>
<td>4.48</td>
<td>320.0</td>
<td>47.3</td>
<td>12</td>
<td></td>
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<tr>
<td></td>
<td>1978</td>
<td>1.40</td>
<td>1.32</td>
<td>310.0</td>
<td>47.1</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Kipapa/16-2128</td>
<td>1974</td>
<td>14.30</td>
<td>13.60</td>
<td>6,860.0</td>
<td>617.0</td>
<td>10</td>
<td></td>
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<tr>
<td></td>
<td>1975</td>
<td>7.30</td>
<td>4.82</td>
<td>1,490.0</td>
<td>134.0</td>
<td>5</td>
<td></td>
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<tr>
<td></td>
<td>1976</td>
<td>8.40</td>
<td>3.55</td>
<td>1,800.0</td>
<td>162.0</td>
<td>5</td>
<td></td>
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<tr>
<td></td>
<td>1977</td>
<td>6.20</td>
<td>4.13</td>
<td>6,640.0</td>
<td>148.0</td>
<td>6</td>
<td></td>
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<tr>
<td></td>
<td>1978</td>
<td>3.70</td>
<td>2.37</td>
<td>1,380.0</td>
<td>124.0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Waikiele/16-2130</td>
<td>1967-69</td>
<td>46.00</td>
<td>1.76</td>
<td>29,000.0</td>
<td>245.0</td>
<td>N/A</td>
<td></td>
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<tr>
<td></td>
<td>1973</td>
<td>17.60</td>
<td>0.23</td>
<td>1,380.0</td>
<td>15.0</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1974</td>
<td>46.70</td>
<td>2.12</td>
<td>52,450.0</td>
<td>443.0</td>
<td>26</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>33.20</td>
<td>1.94</td>
<td>29,240.0</td>
<td>247.0</td>
<td>26</td>
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<td>35.40</td>
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<td>30,190.0</td>
<td>255.0</td>
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<td>0.27</td>
<td>3,110.0</td>
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<td>Moomahu/16-2273</td>
<td>1972</td>
<td>0.88</td>
<td>5.66</td>
<td>172.0</td>
<td>70.7</td>
<td>1</td>
<td></td>
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<td></td>
<td>1973</td>
<td>0.82</td>
<td>1.23</td>
<td>22.0</td>
<td>8.4</td>
<td>0</td>
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<td></td>
<td>1974</td>
<td>1.42</td>
<td>7.94</td>
<td>328.0</td>
<td>135.0</td>
<td>3</td>
<td></td>
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<td></td>
<td>1975</td>
<td>0.46</td>
<td>8.54</td>
<td>74.8</td>
<td>30.8</td>
<td>3</td>
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<tr>
<td></td>
<td>1976</td>
<td>0.51</td>
<td>2.91</td>
<td>163.0</td>
<td>72.1</td>
<td>1</td>
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<td></td>
<td>1977</td>
<td>0.40</td>
<td>2.91</td>
<td>23.4</td>
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<td>15.98</td>
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<td>240.0</td>
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<td>1972</td>
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<td>3.48</td>
<td>335.0</td>
<td>40.3</td>
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<td></td>
<td>1973</td>
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<td>345.0</td>
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<td>5</td>
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<td></td>
<td>1974</td>
<td>8.96</td>
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<td>870.0</td>
<td>105.0</td>
<td>0</td>
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<tr>
<td></td>
<td>1975</td>
<td>8.55</td>
<td>9.85</td>
<td>600.0</td>
<td>73.1</td>
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<td>1.51</td>
<td>174.0</td>
<td>21.0</td>
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<td>Kamokila/16-2222</td>
<td>1972</td>
<td>2.84</td>
<td>2.78</td>
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<td>112.0</td>
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<tr>
<td></td>
<td>1978</td>
<td>5.13</td>
<td>0.63</td>
<td>310.0</td>
<td>31.0</td>
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### Table 3. Timing of Suspended Sediment Production From Watersheds on Oahu, Hawaii.

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Year</th>
<th>Concentration ≤ (mg/L)</th>
<th>Percent of Total Annual Sediment Discharged</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>98% of Time</td>
<td>90% of Time</td>
</tr>
<tr>
<td>Kalii/21-2290</td>
<td>1974</td>
<td>63</td>
<td>32</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>59</td>
<td>35</td>
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<tr>
<td></td>
<td>1976</td>
<td>27</td>
<td>13</td>
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<tr>
<td></td>
<td>1977</td>
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<td>34</td>
</tr>
<tr>
<td></td>
<td>1978</td>
<td>74</td>
<td>47</td>
</tr>
<tr>
<td>Kipapa/21-2118</td>
<td>1974</td>
<td>161</td>
<td>66</td>
</tr>
<tr>
<td></td>
<td>1975</td>
<td>90</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>1976</td>
<td>102</td>
<td>43</td>
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<tr>
<td></td>
<td>1977</td>
<td>23</td>
<td>29</td>
</tr>
<tr>
<td></td>
<td>1978</td>
<td>100</td>
<td>25</td>
</tr>
<tr>
<td>Waikiale/21-2130</td>
<td>1973</td>
<td>124</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td>1974</td>
<td>400</td>
<td>92</td>
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<td></td>
<td>1975</td>
<td>161</td>
<td>58</td>
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<td>137</td>
<td>59</td>
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<tr>
<td></td>
<td>1978</td>
<td>190</td>
<td>60</td>
</tr>
<tr>
<td>Kualoa/21-3275</td>
<td>1972</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1973</td>
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</tr>
<tr>
<td></td>
<td>1977</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Koolau/21-2705</td>
<td>1972</td>
<td>100</td>
<td>7</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>1974</td>
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<td>30</td>
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<tr>
<td></td>
<td>1975</td>
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<td>12</td>
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<td></td>
<td>1976</td>
<td>50</td>
<td>10</td>
</tr>
<tr>
<td>Koolau/21-2712</td>
<td>1977</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>1978</td>
<td>180</td>
<td>90</td>
</tr>
<tr>
<td>Standard for wet season*</td>
<td>1970</td>
<td>80</td>
<td>50</td>
</tr>
</tbody>
</table>


already exceed the standards, while others are so far below them that significant increases would be allowed. Such standards may be useful in detecting long-term trends and as an index value for all streams. The 1978 standards do not establish a means of measuring the impact of a short-term activity on suspended sediment production. As an example, if a developer cleared a large area before construction began and then a storm occurred, suspended sediment production would likely be much greater than if no disturbance had occurred. However, the event could easily fall within the "less than 2 percent of the time" category, where the 1978 standards allow any sediment discharge level. One storm and one development may or may not be significant, but the accumulated effect of all disturbances during one storm may be very significant.

**ACKNOWLEDGMENTS**

This study was conducted in cooperation with the U.S. Geological Survey, Water Resources Division, which installed and maintained the automatic water samplers at Kipapa, analyzed all samples at its Honolulu laboratory, and provided most of the data summarized here.

**LITERATURE CITED**


Honolulu Board of Water Supply, 1963. Oahu Water Plan, City and County of Honolulu, Honolulu, 67 pp., illus.


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Figure 2. Stream Flow and Sediment Concentrations During a Moderate Rainfall Event, Kipu Stream.

Figure 3. Stream Flow and Sediment Concentrations During a Moderate Rainfall Event, Kalihi Stream.

Table 4: Relation of Instantaneous Stream Flow to Instantaneous Suspended Sediment Discharge on Two Watersheds, Oahu, Hawaii.

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Year</th>
<th>Number of Samples</th>
<th>Equation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalihi/16-2790</td>
<td>1974</td>
<td>96</td>
<td>Y = 0.014X + 0.76</td>
</tr>
<tr>
<td>1975</td>
<td>34</td>
<td>0.96</td>
<td>Y = 0.006X + 1.95</td>
</tr>
<tr>
<td>1976</td>
<td>49</td>
<td>0.90</td>
<td>Y = 0.001X + 1.82</td>
</tr>
<tr>
<td>1977</td>
<td>28</td>
<td>0.31</td>
<td>Y = 0.018X + 1.48</td>
</tr>
<tr>
<td>1978</td>
<td>43</td>
<td>0.21</td>
<td>Y = 0.040X + 1.50</td>
</tr>
<tr>
<td>Pooled</td>
<td>225</td>
<td>0.87</td>
<td>Y = 0.013X + 1.78</td>
</tr>
<tr>
<td>Kipu/26-212B</td>
<td>Selected Data</td>
<td>106</td>
<td>0.93</td>
</tr>
</tbody>
</table>

*Y = suspended sediment discharge (kg/lhr); X = water discharge (m³/s).

WATER RESOURCES BULLETIN
Figure 4. Suspended Sediment Discharge Plotted Against Streamflow, From Kalii Stream (relationship based on the pooled data where $Y = \text{sediment suspended}$ and $X = \text{stream flow (m}^3/\text{ssec})$).
K Channel-Lock
Flexible Concrete Revetment,
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- Withstands the most rigid testing in the industry today

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- Reduces horizontal movement and vertical lift with its unique shape and geometric design
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- Bridge Abutment Protection
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- Pipeline or Cable Crossings
- Protection of Boat Ramps

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- Rock Rip Rap
- Grouted Mattress
- Grouted Rock Rip Rap
- Poured Concrete
- Gabions and Reno Mattress

<table>
<thead>
<tr>
<th>Channel-Lock™</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Blocks</td>
<td>450</td>
<td>550</td>
</tr>
<tr>
<td>Height</td>
<td>4½ in.</td>
<td>5½ in.</td>
</tr>
<tr>
<td>Weight Per Sq. Ft. (Approx.)</td>
<td>32 lbs.</td>
<td>40 lbs.</td>
</tr>
<tr>
<td>Surface Area</td>
<td>1.78 sq. ft.</td>
<td>1.78 sq. ft.</td>
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<tr>
<td>Weight of Block</td>
<td>57 lbs.</td>
<td>71 lbs.</td>
</tr>
<tr>
<td>Concrete Strength</td>
<td>4,000 psi</td>
<td>4,000 psi</td>
</tr>
<tr>
<td>Open Area (Approx.)</td>
<td>20%</td>
<td>20%</td>
</tr>
</tbody>
</table>

| Mattress (With Cables)   | 450      | 550      |
| Standard Width           | 8 ft.    | 8 ft.    |
| Standard Length          | 40 ft.   | 40 ft.   |

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Channel-Lock™ does a superior job of erosion control:

**Stable** – Unique, strong, interlocking blocks make the whole job one integral system.

**Flexible** – The design allows the whole system to adjust to changing grades.

**Relieves Hydraulic Pressure** – Approximately 20% of the system is open, relieving hydraulic uplift forces, preventing cracking or displacement that can lead to system failure.

**Appearance** – Channel-Lock™ allows for revegetation in the voids in the system or allows fill with native materials to enhance appearance. No sharp, rough surfaces to cause injury or collect debris.

**Accessibility** – Channel-Lock’s™ finished, uniform surface area allows for normal maintenance equipment and pedestrian traffic.

**Durable** – Constructed of 4,000 PSI concrete for long life, yet flexible to adapt to changing grade and hydraulic conditions without failing.

**Environmentally Friendly** – Open areas in this stable yet flexible system allow for maximum adaptation to the original environment. Native vegetation, soil or rock can be used to return the site to its natural state.

**Ease of Installation** – Channel-Lock™ can be hand-placed without the use of heavy equipment or is available in mats with cables.
Channel-Lock™ is an economical, environmentally friendly and effective solution to erosion problems. In many cases, it is the superior alternative to conventional erosion control materials for revetment and channel.

The unique, octagon-shaped, interlocking concrete block are placed on engineered geotextile filter fabric to protect against soil erosion. The open areas in the system allow for relief of hydraulic pressures to ensure system integrity throughout the installation. The interlocking block allows for flexibility throughout the system to adjust for changing soil conditions while maintaining the lateral stability of the system.
Copper, Brake Pads & Water Quality,
City of Palo Alto, DPW.
Copper, Brake Pads, Water Quality

Briefing Packet

Developed by the City of Palo Alto and Common Ground for the Environment

date: 02/17 - 94

Brake Pads and San Francisco Bay Questions and Answers

Copper and other toxic metals threaten the health of many valuable species in San Francisco Bay. Brake pads are a major source of copper in the environment. This document explains the situation and what can be done about it.

What's The Problem?

Copper and other heavy metals are a problem for San Francisco Bay. Copper, lead, and other heavy metals are toxic to aquatic life in very low concentrations (parts per billion). Heavy metals can accumulate in the food chain, concentrating in larger species such as fish.

An assessment of copper concentrations in the Bay shows that much of San Francisco Bay exceeds the adopted water-quality objectives for copper. Due to evidence of water-quality impacts related to copper, lead, and other metals, the United States Environmental Protection Agency (U.S. EPA) has designated the southern reach of San Francisco Bay (south of the Dumbarton Bridge) as an impaired water body under Section 304 (f) of the Clean Water Act.

Local and regional agencies charged with protecting the Bay's water quality—such as municipal wastewater treatment plants and stormwater pollution prevention programs—are undertaking numerous programs and strategies to reduce the levels of copper and other heavy metals in the Bay. Special efforts have been made to reduce copper discharges, including a broad-based copper discharge reduction plan (containing a 20% reduction requirement for ports sources) adopted by the San Francisco Bay Regional Water Quality Control Board.

Everyone is looking for the best way to achieve the needed copper discharge reductions.

Businesses have played an important role in the metals discharge reduction effort. Regulatory programs to reduce copper discharges have had a particularly significant impact on the operations of San Francisco Bay Area manufacturing, metal plating, and computer industries.

Automobile Wheel with Disc Brake
Why Is Brake Pad Dust a Concern for Water Quality and Environmental Protection?

About 33 percent of the total amount of copper and 1 to 4 percent of total lead discharged to southwest San Francisco Bay comes from vehicles’ brake pads. This means that disc brake pads are one of the largest sources of copper discharge to the Bay, and a significant contributor to the Bay’s pollution problem.

The estimates shown do not include possible contamination from drum brakes. Although drum brakes used to be popular, they are gradually being phased out in favor of disc brakes. Many cars today have disc brakes on all four wheels or disc front/drum rear braking systems. These trends indicate that disc brakes will probably increase in popularity in the future, though to date only 15 percent of disc brakes.

What Are Brake Pads Made of?

Brake pads are made from one of several types of "friction materials," that are generally classified as "metallic," "semimetallic," or "organic." Organic brake pads contain no metal. While organic brake pads have remained the same, most manufacturers have increased emphasis on their formulations for safety reasons. "Metals" and "semi-metals" brake pads are no longer used because of their presence of toxic metals, but not all brake pads contain copper and other heavy metals.

The use of copper in brake pads is limited by the highly toxic nature of copper compared to the use of alternative materials. Copper contents can vary from manufacturer to manufacturer and even among pads made by the same manufacturer. The range of copper content in a group of disc brake pads analyzed by the Spina-Chis Valley Napa County Pollution Control Program was from 0.8 percent (below 0.00625 percent) to 20.1 percent. Lead and zinc have also been found in some brake pads. All types of brake pads (organic, semi-metallic, and metallic) can contain copper.

How Do Brakes Work?

Most cars today have disc brakes. Disc brake work the bicycle hand brake: depressing the car’s brake pedal causes a pair of brake "pads" to squeeze a metal disc on each wheel. Friction caused by the brake pads stopping the disc slows and eventually stops the car. While the car is stopping, friction also wears away a very small amount of brake pad material. Eventually, after about 30,000 to 50,000 miles, the pad must be replaced because so much brake pad material has worn off.

Drum brakes use two semi-circular brake pads ("brake shoes") mounted inside a covered cylinder (the "dumah"). To stop a car, the brake shoes move outward, applying force against the wall of the cylinder. Like disc brake pads, drum brake shoes wear away, and eventually need replacement. Since the brake cylinder is a loose consumer, some of the brake pad dust remains inside the cylinder until it is opened for a repair.

Although a small amount of the dust that comes off of brake pads during stopping within the roadway or road dust in the rain or when the car is washed. Unless a street sweeper selects the brake pad dust that lands on the road, this "friction material" is eventually washed to a storm drain by rain.

How Does Brake Pad Dust Get into San Francisco Bay?

Once it comes off a car, brake pad dust can fall on a road or travel through the air. Either way, the dust can fall into or be washed into the Bay.

In 1981, parts of the San Francisco Bay Area, as in most of the U.S., storm drains flow directly to creeks and the Bay without treatment. In some older catchments, even around the U.S.—including many of San Francisco—storm drain systems are connected to sanitary sewers, so that storm drain waste material enters the Bay. In general, anything that gets into a storm drain eventually flows into creeks, rivers, and bays.

Some brake pad dust is fine dust. It can travel through the air the same distance. Dust that originally falls on a road surface can be broken into fine particles and traveled up into the air by storm events. This particular matter, often called PM4, (particulate matter less than 10 micrometers in diameter) can remain suspended in the atmosphere for some time, eventually washing back out of the air with rain and dew. Brake pad dust that washes out of
the air can settle directly into a creek or the Bay, or can fall onto land where it can be washed by rain into storm drains.

How Much Brake Pad Dust Gets into San Francisco Bay?

A study by the Santa Clara Valley Nonpoint Source Pollution Control Program (a local government stormwater pollution prevention program) estimated that almost half of brake pad dust probably reaches the Bay, either through storm drains, or through deposition from the air. This estimate was based on a series of studies conducted by the Federal Highway Administration on highway stormwater runoff.

Do Brake Pads Cause Problems For Other Water Bodies?

While the relationship between water pollution and brake pads has not been studied in other parts of the country, many other rivers, lakes, and bays (including Chesapeake Bay and Narragansett Bay) have copper problems. Brake pads are a major contributor to these problems. State and Federal government agencies like the U.S. EPA have the data necessary to identify water bodies where brake pads may be a significant contributor to water pollution.

What Can Be Done?

Preventing pollution by eliminating the use of copper, lead, and other toxic metals in brake pads would be substantially more effective than attempting to control this pollution through efforts such as street sweeping. Because zero-copper and low-copper brake pads are currently certified as safe and used in many vehicles, it appears that the use of copper is not necessary for brake pads to function properly. Therefore, reducing or eliminating the presence of copper in brake pads should be technically feasible.

But advisably copper in brake pads may not be necessary to effect significant improvement in the health of the Bay. For the southern reach of the Bay, a 50 percent reduction in the copper discharge from brake pads would mean that 17 percent reduction in total copper discharge—more than would be achieved by shutting down all three Santa Clara Valley sewage treatment plants! In conjunction with other copper pollution prevention efforts, a reduction of this magnitude might be enough to get the Bay close to or even in compliance with water quality standards.

A 50 percent reduction in copper discharge from brake pads could be accomplished in one of two ways: either by eliminating copper from the high-copper brake pads, or by removing half of the copper from all copper-containing brake pads.

How Safe Are Brake Pads That Don't Contain Copper?

While copper is used in some brake pad formulations (apparently to provide friction stability), other brake pads contain little or no copper. Copper is used extensively in semimetallic brake pads, particularly in European and Japanese vehicles. But it also may appear in metallic and "organic" brake pads. Copper-free brake pads of all types (metallic, semimetallic, and organic) are widely available and in commercial use.

Because zero-copper products are currently used in many vehicles in accordance with federal vehicle safety standards, it appears that the presence of copper is not necessary for brake pads to function safely.

How Can We Reduce The Copper Content of Brake Pads?

A voluntary partnership between industry and public agencies offers the best and most expedient solution to the problem of copper pollution from brake pad wear. EPA's Green Lights Initiative is one example of a successful program, designed to encourage businesses to switch to energy-efficient lighting. Reductions in the copper content of brake pads may similarly be achieved through a voluntary partnership with vehicle, brake pad, and fictional material (pad surface) manufacturers. By reformulating brake pads to contain less copper, manufacturers can save on the use of raw materials and enhance their image as environmentally responsible companies.

Alternatively, water pollution from brake pads could be controlled through federal or state regulations. While a regulatory approach is possible, it would involve substantial time and potentially significant costs for both government and industry.

With active, effective partnership between government and manufacturers, a voluntary solution is possible. To succeed, the U.S. EPA, California EPA, local governments, community members, automotive manufacturers, brake pad manufacturers, and the makers of friction materials will need to work together to protect the environment.

The photographs in this document were obtained with the assistance of Larry's AutoWorks (Mountain View, California). Sample brake pads shown in the first photograph were provided by Larry's AutoWorks (Mountain View, California) and Andreas Heads (Palo Alto, California).
How Can We Reduce the Amount of Copper in Brake Pads?

A voluntary agreement between industry and public agencies offers the least and most expeditious solution to the problem of copper pollution from brake pad wear. EPA's Green Lights initiative is one example of a successful program designed to encourage businesses to switch to energy-efficient lighting. Reductions in the copper content of brake pads may similarly be achieved through a voluntary partnership with vehicle, brake pad, and friction material (pad surface) manufacturers.

- Copper-free brake pads are readily available and meet safety and performance standards.
- Industry mechanisms and business structures could provide incentives for the necessary changes without regulatory action.
- The industry's voluntary reduction of asbestos use in brake pads provides a successful precedent.

By reformulating brake pads so contain less copper, manufacturers can save on the costs of raw materials and enhance their images as environmentally responsible companies. For governments agencies, a voluntary partnership provides the opportunity to move beyond the traditional command and control approach and toward a cooperative effort aimed at a sustainable economy and environment through prevention of pollution at the source. The Brake Pad Partnership can become a model for addressing other pollutants identified through regulatory programs.

Next Steps

Initial coordination of the Brake Pad Partnership has begun. Answers to some of the most pressing questions have already begun to be identified, including: the nature of the industry's methods, the national significance of copper pollution, and the potential for voluntary copper reductions. Contacts with and briefings of key stakeholders have also been initiated, including local, state, and federal government agencies as well as industry associations and technical experts. The Partnership should begin business meetings in 1996. The next steps in the development of the Brake Pad Partnership include:

- Continue discussions with vehicle, brake pad, and friction material manufacturers. Begin to explore voluntary reductions in the amount of copper in brake pads. Issues to be explored in the Partnership dialog include:
  - How much copper is used in brake pads and what functions does it serve?
  - What are the future trends in industry's use of copper in brake pad formulations?
  - What capacity does the brake pad industry have for change in copper levels?
  - How could alternative formulations affect the environment?

- Confirm that a reduction in the copper content of brake pads does not affect braking safety. Since many non-copper brake pads are currently available and meet safety standards, there does not appear to be a relationship between the presence of copper and braking safety; nevertheless, this assumption should be confirmed by manufacturers.

- Identify other water bodies that are impacted by copper and other heavy metals found in brake pads. Data from the U.S. EPA and other sources can be compiled and analyzed to ascertain the national significance of copper pollution and to evaluate the national implications of copper discharge from brake pads.

- Improve understanding of the relationship of copper released from brake pads to toxicity in aquatic ecosystems. Past, current, and future studies can provide a more detailed understanding of the relationship of brake pad copper release to water quality and effects on aquatic ecosystems.

Resources to support the Partnership through its completion will be needed. Elements of the Partnership most likely to require funding are administrative costs and research. Technical research will likely be necessary to supplement existing data with regard to the relationship between brake pad wear and surface water quality.
Sources of Copper

Copper is discharged to surface water from many sources, including both stormwater runoff (which typically receives no treatment) and municipal and industrial wastewater treatment plants. Copper also reaches creeks, bays, and estuaries through deposition of airborne materials, via leachate flows from abandoned mines, and from agricultural runoff containing pesticides. The relative importance of these copper sources varies among water bodies.

Sources of Copper Discharges to San Francisco Bay

The San Francisco Bay Regional Water Quality Control Board has determined that stormwater runoff and abandoned mines are by far the greatest sources of copper discharge to the Bay. In some areas, stormwater is the major source.

Almost everywhere in the San Francisco Bay area, stormwater runoff is carried by storm drains or creeks directly to the Bay. It is not treated prior to discharge. For many reasons, it is generally considered impractical to provide treatment for runoff. Preventing pollution by eliminating the discharge of pollutants at the source is the most practical and cost-effective method of reducing stormwater released pollution of creeks and the Bay.

A study prepared by the Santa Clara Valley wastewater program ("Contributions of Heavy Metals to Storm Water from Automobile Disc Brake Pad Wear, Woodward-Clyde and Santa Clara Valley Nonpoint Source Pollution Control Program, October 1994") indicates that brake pads are one of the largest single sources of copper in stormwater runoff. In no particular order, other sources of copper in stormwater runoff include:

- Driveway pads
- Motor vehicle exhausts
- Deposition of air pollutants
- Automotive fluid leaks
- Automotive wrecking yards
- Weathering and storage of debris
- Vehicle tires
- Improper disposal of paint, oil, coolants, and other wastes
- Illegitimate storm drain connections and illegal discharges to storm drains
- Vehicle wash water
- Water supply
- Corrosion of copper piping
- Cooling water discharges

- Use of copper-containing pesticides (including rodenticides, cooling tower additives, pool algicides, landscaping products, gardening products, and agricultural products)
- Discharges from mobile cleaning operations (such as car washes, mobile vehicle washing, building and plaza cleaning, parking lot cleaning, and carpet cleaning)
- Swimming pool, spa, and fountain discharges.

Quantitative Estimate of Copper Sources

Using data assembled in the South Bay Copper Reduction Diving (Monitoring of Understanding) (1994), it is possible to estimate the significance of brake pads as a source of copper discharge to the southern reach of San Francisco Bay (south of the Dumbarton Bridge). Copper from disc brake pads is estimated to make up more than one third of all copper discharge to the southern reach of the bay—more than twice as much copper as discharged by all other wastewater treatment plants combined.

Sources of Copper in South San Francisco Bay

Such estimates have yet to be prepared for other portions of the Bay and for other water bodies. Nevertheless, given the relative importance of brake pads as the biggest source for South San Francisco Bay, it is likely that brake pads are a significant contributor to copper problems in other water bodies in urbanized areas.
THE FATE OF COPPER IN BRAKE PADS: A SUMMARY
M Waikakalaua Stream Realignment Project
Troy Ogasawara
Hawaiian Fertilizer Sales.
Waikakalaua Stream Realignment Project

by Troy A. Ogawa, Vice President, Hawaiian Fertilizer Sales, Inc., and Aim C. Joaquins, President, The King's Landscape Company

Introduction

Land continues to become a precious commodity in Hawaii, as in many other areas. The relatively high cost of land in Hawaii has forced developers to employ innovative approaches to maximize developable areas. In order to prepare building pads and road bases on the valley floor, cut and fill techniques are essential. The establishment of vegetative cover on steep and highly erodible slopes has always presented a challenge at Launani Valley, located in central Oahu, Hawaii. Gilbert Scott, representing Towne Realty, was the developer for Launani Valley.

A condition of the development permits required Waialua Joint Venture to vegetate all cut and fill slopes. In total these were in excess of 2.43 hectares (6 acres) of slope face created during construction. These slopes ranged from 2:1 to 0:1 and in some cases, vertical. Slope heights varied from approximately 18.79-23.53 m (60-77 ft) and between 9.14-15.29 m (30-50 ft) cut and fill, respectively. Being situated along the valley walls, these slopes remained relatively inaccessible from their tops. In addition, the Waialua stream ran along the base of approximately two-thirds of the slopes. In such instances, a 21.36-27.43 m (70-90 ft) span over the stream rendered these slopes inaccessible from both top and bottom. These conditions added further constraints in utilizing conventional stabilization and vegetation techniques.

An initial soil test indicated an extremely poor nutritional status. This soil was infertile, exhibited an extremely high hydrogen base saturation percentage and low phosphorous levels. Being of volcanic origin, extremely low soil pH and situated in a high rainfall zone, it would be plausible to consider aluminum and manganese toxicity as an additional factor in the establishment of any vegetative cover. In 1994, the National Weather Service reported over 354 cm (100 in) of rain at its adjacent Mililani Mauka Station between January 1994 and July 1995.

Historically, the standard planting and erosion control practices consisted of hand broadcasted Weedetta mililolololahlavna cover grown in jute netting, then capped with tacked mat. This method proved to be effective on moderate slopes, consisting of friable soil types. Slopes with a grade of 1:1 and greater, which consisted of friable infertile soil profile, presented difficulties in complete vegetation via this means.

Site Considerations

Taking into consideration the many inhibiting factors, standard planting practices were not feasible, nor effective. With respect to establishment, the depleted soils encouraged root development into the bonded fiber mats and jute net blanket used for erosion control rather than the soil substrate. Success of the project would be contingent upon properly addressing each of the following factors.

1. Ability to cost-effectively stage and safely install materials under the prevailing site conditions.
2. The stabilization of friable soil to the stable underlying substrate. This layer ranged from 0.2 to 0.35 m (6-10 in) in depth.
3. The ability to provide for "transitional binding" (erosion control) which would allow for gradual degradation as the selected plant material secures its roots deeply into the soil profile.
4. The extreme nutrient deficiencies of phosphorus, potassium, magnesium and calcium required corrective action.
5. Due to the occasional high wind gusts, severe slopes, long slope faces, unpredictable weather, and inaccessibility, proper irrigation distribution presented an obstacle.
6. Being in close proximity to a stream, the methods employed must not prevent an environmental hazard.

Material Selection and Design Considerations

A cementitious gypsum base geobinder

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An added benefit of utilizing gypsum plasters in the particular edible soil zone is its ability to supply available calcium and sulfur as the dominating seedlings. A high phosphorus slow-release fertilizer and a nitrogen-fixing legume, Centrosema pubescens (Tropical Sun Hemp) was combined in the hydraulic slurry to provide long-term fertilization.

Alumina (Permutit) polyhydroxide was selected due to its aggressive growing habit, drought tolerance, and extensive root and nodon system. Amended sewage sludge (thick sludge) served as a source crop whose various root structures provided short-term soil stabilization. Tropical Sun Hemp provided a natural long-term nitrogen source.
SOIL STABILIZATION

supply on an otherwise difficult to fertilize slopes.

A deep irrigation system was selected to overcome high wind conditions. Severe slopes and limited water supply. Furthermore, a conventional irrigation system would have been susceptible to damage during flash flood conditions. Such floods have been known to increase stream levels up to 35 feet. Therefore, a vertical system was installed along the stream bank slopes. A horizontal system was installed on the remaining slopes.

Observations and Conclusions:

Step 1. The bonded fiber mat was spread to achieve the underlying stable inert material to the unstable friable surface material. The high volume of aqueous Gypsum Based Land Planner/Geobinder, combined with Organic Yard Based Tackifier, provided the profile and created an effective erosion control technique. When allowed to harden and cure, the loose crumbly soil particles became a stable matter-firm base for seeding.

Step 2. Proper distribution of the seed and fertilizer components achieve intimate contact with the stabilized soil surface. This促进了 deep root growth into the soil. An indicator dye was also utilized to ensure even deposition of the seed seeding mixture.

Step 3. The heavy-bonded fiber matrix application provided an armor-like coat which protected the seed and fertilizer from rainfall impact, wind erosion and water shearing. When installed properly, this film was 0.04 cm (1/8 to 1/4 in) coating the surface and hardness of a paper egg carton. After curing, subsequent rainfall and irrigation slowly dissolved the Gypsum based material, which in turn fertilized the soil with additional calcium and sulfur. As germination and establishment progressed, the "transition-binding" agents gradually lost their effectiveness, while the long-term vegetation stabilization matured.

Normal irrigation was initiated approximately 24 hours after the final coat application. Germination of rye grass occurred in 4 days. Full establishment of the Kelipuygrass and Topical Susi Hemp was attained in 2 months.

A minor failure occurred on a near-vertical portion, in a linear increase. A 5 ft diameter section fell as a result of poor penetration of the initial Step 1 profile binding coat. Initially, a small collar detached from the face of the slope. The small opening in the armor coating and poor profile attachment to the parent material caused this incident. The small void, undergained by irrigation and rainfall, developed into a large hale spot. This demonstrates the necessity of the initial Step 1 profile binding technique.

Three-step application process accomplished the stabilization desired with complete and uniform establishment of vegetation, while also being cost-effective and environmentally sound method.

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- Excisor Logs

For more information, contact Troy A. Osaniwine, Vice President, Hawaiian Fertilizer Sales, Inc., 54-155 Lualua St., Waipahu, HI 96797. [Contact Information]

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Port of Seattle Study Recommends that Sweepers Can Replace More Expensive BMP's for Removing Metals
Submitted by: Jackie Parnell
Environmental Planning Consultant
Honolulu.
Features

Where it All Started
This excerpt from Benjamin Franklin's autobiography shows why this icon of American history is considered by many to be the 'Father of Street Sweeping.'

Air Quality Sweeper Testing
Another veteran sweeper researcher calls for comprehensive national testing standards.

Setting Their Sights On Perfection
Atlanta Sweeping is working to redefine quality in contractor-based sweeping services.

Raceway Sweepers Must Really Perform
When a sweeper is used on race tracks, there’s no room for error. Representatives of America’s newest NASCAR facility and an NHRA track manager provide insight.

Port Of Seattle Commissions Sweeping Study
Study recommends that new EV series pavement cleaners can replace more expensive BNDs.

United We Sweep
Northern California contractors form an association dedicated to professionalism.

Refurbish Those Older Sweepers
The purchasing manager of one America’s largest property development firms shares what he’s learned about the wisdom of sweeper refurbishment.

Roto-Milling
Many contractors describe sweeping after a roto-mill as the toughest job in the business. Three roto-milled contractors discuss why you need experience — and tough equipment.

Planning, Quality, Honesty
BJ Sweeping does the job the old fashioned way, but providing quality service every time.

Cleaning Up After Mardi Gras
Cleaning up after what may be America’s biggest party is a logistical nightmare. To the veteran sweeping team in New Orleans, it’s just another parade, just another year.

Landfill Fees and Space
What can we expect for future tipping fees and landfill space constraints? Jim Thompson, president of Chartwell Information, Inc. provides an insightful look at this topic.

About our cover...
This Schwarze EV1 pavement cleaner is shown at work at the Doe Run Company’s and aluminum plant in Reynolds, Missouri. Driving the EV1, the operator can now clean in below freezing weather conditions, and a single operator can perform an 8 hour shift because the EV1’s blowing system reduces the concern about dust pollution.

Departments

View From The Top
Schwarze Industries’ purchase of the patented EmiozWhirl waterless sweeping technology moves the industry’s best available technology from ‘sweeping’ to ‘cleaning.’ This analysis by company president Nick Schwarze provides his insight on this new breakthrough.

Industry Update
New products, new changes in the industry.

Feedback From the Field
Schwarze Industries’ warranty manager discusses why it’s so important to get warranty advice on tires before they get worn.
We All Must Listen To The Wind

There's no longer any denying our country's environmen-
tal winds of sweeping change. The first whispers started just a
couple of years ago, as a soft onshore breeze striking only
America's coastlines. In recent times, however, the force
from along our waterways has become a gale, and now the first breezes
are being felt from the heartland.

As with every unasked-for change, some have pretended that
nothing is happening. Others, resisting disruptions in their sta-
tus quo, are hoping it will simply go away. An increasing number,
though, are recognizing that this movement represents the dawning
of an exciting new era for sweeping. As with any dynamic situation, however, to
remain ignorant will require education about, and adaptation to, the emerging requirements.

Benjamin Franklin, one of our foremost statesmen and pioneers of the entre-
preneurial spirit, epitomized the ability to succeed through 'inventive adaptation.'
We start this issue with the portion of his autobiography in which he modestly
proposed, back in the 1750s, the basic advantages to be found by sweeping the streets
of London. This word-for-word excerpt shows why many consider Franklin to be the 'Father of Street Sweeping.'

Another such person is investor Ken Wilkerson, a man whose brilliant adapta-
tions to the train derailment industry are now having a broad-based impact on
sweeping. In combination with another person of vision, Mark Schwarze, president
of Schwarze Industries, Inc., Wilkerson's EnviroWash technology is propelling sweep-
ing to a new level of effectiveness and professionalism. Although this won't take
place overnight, it will occur — because the need for this advancement is so great.
Sweeping's producers and users of the EnviroWash technology has already
changed forever some of the most fundamental, basic, premises of sweeping. When
you read about this quantum technological leap, covered on pages 14 and 22, I be-
lieve you'll agree there's no going back.

Chuck Sarnerfield provides his insight (page 6) on how sweeping can affect air
quality and introduces some important ideas on reducing dust output even on cur-
rent mechanical broom sweepers. Well-known researcher, Roger Sutherland, also
unveils the results of his new study commissioned by the Port of Seattle (page 16).
This is the most conclusive evidence so far that advanced technology pavedroad clean-
ing can have a very positive impact on reducing pollutants in stormwater runoff.

In this issue you'll also be reading about some other people who are committed
to producing the best results possible. We take a look at Atlanta Sweeper (page 10), a
company that's advancing at breakneck speed not because they provide low cost
services, but because of a total commitment to attaining zero customer complaints.
Our other featured contracting firm, BJ Sweeping (page 33), has also attained its suc-
cess by making the provision of quality services a company trademark.

Ever wonder what some of the toughest sweeps in the country might be? We
cover three contenders for that category (across page 16), sweeping after a roto-
roll (page 30), and cleaning up debris you have to see in order to believe, the
aftermath of Mardi Gras (page 34). Additional inspiration comes from the director of
America's newest sweeping association, the United States Street Sweeping Associa-
tion (page 20), as well as from the person in charge of the sweeping program for
Crown American, one of the largest property management firms in the U.S. (page 28).

There's a host of useful information packed into this issue of American Sweeper.
As you read the insights from this wide cross-section of innovative people, I challenge you
to formulate ways to use it to create a positive impact within your own organi-
ation. Armed with the knowledge packed into these 40 pages, you can have a tre-
mandous influence on the policies and quality level around you. Don't just read
about it: in the immortal words of Star Trek's Jean Luc Picard, "Make it so."
Port of Seattle Commissions Sweeping Study

Sweeping up fines could save $16 million over the cost of previous stormwater runoff control solutions.

by Ranger Kidwell-Ross

One of the latest sweeping studies involves a 250 acre expansion of a container storage facility by the Port of Seattle. The yard at the proposed site, as well as that of the current location, is 100% paved. At the site, containers are taken off of ships, then moved around, stacked, put onto trailers, etc. Plus, semi trucks bring in containers and leave with full ones. The Port facility is a major shipping nexus of the west coast, and so it is a very active operation.

As part of their expansion requirements, the Port was faced with an $18 to $20 million stormwater control cost. For this type of expansion, one of the best management practices recommended by the Washington State Department of Ecology (WDOE) is the installation of huge underground boxes, called 'wet vaults.' These are designed to catch stormwater runoff and then settle it. Because of the cost, the Port of Seattle hired Roger Sutherland, of Karabalin and Associates, Inc. to conduct a study. Sutherland's mandate was to see if an alternative to the wet vaults might work just as well but cost less.

"We collected 2 months worth of data," said Sutherland, "which is the accumulation of sediments on an existing yard almost identical to the proposed expansion." A Seattle stormwater consultant, Gary Martin of Resource Planning Associates, had assumed the sedimentation that collected at 9 test sweeping sites, each 2,000 square feet in size. At varying frequencies, ranging from weekly to every four weeks, he went out and collected what was on the pavement surface at the various accumulation sites, using a hand broom and a shop vac. That provided the information on how rapidly materials accumulates on the pavement after each time it is hand cleaned.

During this two months time frame, eight significant rainfall events occurred, and their depths over time were recorded.

"We used our SIMPTM computer model," continued Sutherland, "to evaluate whether a street sweeping technology can be competitive with the pollution load that can be collected by the wet vaults. This model uses the data we collected in Las Vegas, NV and Centuria, IL, using the advanced technology Envirowhirl sweepers' ability to pick up street dirt. We have conducted several studies on this machine, and have found it to be far superior to any other sweeper in the marketplace.

"Through the real data collected along with the results of the computer modeling study that went along with it, the conclusion is that high efficiency pavement sweeping, conducted on a weekly basis in conjunction with annual catch basin cleaning, can be, and appears to be, competitive with the wet vaults. The wet vault appears to be more efficient than the net result of the sweeping along with traditional catch basins. However, when it is understood that there is a solvable amount of certain types of pollutants, like metals, that exist in the material that's lying on the pavement surface in a dry format, it appears that the sweeping can be just as competitive as the wet vault, if not more so, when it..."
Sweeping can be more effective than wet vaults at removing difficult pollutants like dissolved metals.

The bottom line of the results from this model study is that when the large wet vault concept is compared to weekly sweeping (along with annual catch basin cleaning), then the vaults have a 50% reduction in annual Total Suspended Solids (TSS) washoff by stormwater runoff. The sweeping/catch basin concept has a TSS reduction of 65% annually. However, in total phosphorous removal the two methods appear to be close, at 45% annually for wet vaults and with sweeping/catch basins at 55%. Wet vaults are projected to remove 80% of leaf annually, with the sweeping/catch basin technology reducing S by 60% annually. And with zinc, which trends to be a more dissolved metal, wet vaults are projected to remove 45% annually and sweeping/catch basins at 50%. All of these reductions are in relationship to an annual rainfall simulation with no control assumed to be in place.

The answer appears to be: Why spend $18 million to install a wet vault when, over a life cycle basis, the sweepers can be purchased and operated for about $2 million? We think the results of this study may establish a direction for high efficiency street sweeping, especially since the empirical results show it to be better than some of the other traditional best management practices (BMPs) which have historically been used and are therefore grandfathered in.

With Clasa, an ethnometaphor with the NVDOE, it involved with the decision making of that agency. As part of his job, Clasa is currently working on an update to the Stormwater Management Manual, which will then become the new Washington State Stormwater Manual.

“Our requirement at WDOE is that the Port of Seattle will have to install appropriate BMP’s to control pollutants and runoff,” said Clasa. “That’s why we’re considering the EnviroWhirl [now Schwarze EV-series] sweeper. The remaining pollutants they need just some basic additional cost-effective best management practices. That will be tax yet to be determined. We have not yet decided, between the Port of Seattle and Ecology, what will be an acceptable BMP for what remains after sweeping. They’re talking about using some efficient catch basin technology, as opposed to wet vault, and we’re also looking into catch basins slotted, as a newer technology for removing the pollutants—mostly suspended solids—that are left.

The Port’s study showed that the EnviroWhirl sweeper removed most of the soluble pollutants than the wet vault, and that’s where the good. However, one of the concerns is that, although some studies may have been shown to be efficient for some particles, it could only get to a certain percentage of the yard. I think in one section of the yard it can only get to about 6-10%.

Sweeping is also not at effective during rainfall conditions, which time some pollutants may be discharged. So that safety net, and the leading that would be discharged during those times when the sweeper is either not effective or not available, that we have to look at for additional pollutant control.

“The Port is looking for a more cost-effective approach, and nobody could argue with that. We have to look at it from the standpoint of residual pollutants, ones that remain after applying the appropriate BMPs and that are acceptable in terms of water quality impacts.”

Dave Torseth is an engineer with the Port of Seattle, who is closely watching the Port’s expansion plan alternatives. “Based upon the study by Kurashashi and Associates,” said Torseth, “the Port of Seattle feels comfortable in our proposal for using an EnviroWhirl technology machine as a BMP. We’re now in the position of trying to make the Washington State Department of Ecology (WDOE) feel comfortable with it.

“The Port of Seattle is pretty convinced that the EnviroWhirl/technology represents a significant leap in terms of what the sweeping industry has to offer, and that’s why we’ve gone as far as we have. In the demonstration we saw in September of 1998, the machine did a pretty amazing job of picking up the particulates. It did a good job on both wet and dry pavement. The biggest issue we’re facing with the agencies is that they’re not as familiar with it yet, so they’re not as comfortable with what the machine has to offer. As it becomes accepted throughout the industry, that will help with places like government agencies. From what we have seen, and from the results presented, it is the study by Kurashashi and Resource Planning that we trust, and we think this project merits the use of one, and perhaps two Schwarze EV-series sweepers, as soon as we gain win approval from Ecology WDOE.”

“There are two issues going on here, it’s the WDOE’s hesitation. One is that we’re trying to compare this new sweeping technology against a wet vault alternative, and there’s some questions about...” (continued on p. 37)
sort of thing on them. Most people quickly realize that’s not a good idea, however,” he said with a chuckle.

The French Quarter poses even more problems, due to its narrow streets and unbelievable curb line debris piles. “In the Quarter, the sweepers can only go half a block before dumping,” said Terrell. “Everything but the bar stools are in the street. The debris piles are so high that we have people out in front walking and poking it, making sure there’s nothing in there that shouldn’t be swept. Police on horses go ahead of the equipment, and it’s virtually wall-to-wall people when we start in.

“Technically, the streets like Bourbon Street are only two sweeper-widths wide. We stagger one sweeper on each curb, then run another machine directly behind each of those, then one up the middle and two on each side behind that one. Debris is so thick that about every half block the lead sweepers have to stop and get stuck under the foot of the street, the people will fill it back up because then the bars start to sweep out their doorways, etc. It’s quite a sight to see, and takes a high level of coordination on everyone’s part.”

After seeing it for myself, I couldn’t agree more. The city and BRS crews do a great job under some of the most challenging conditions imaginable. I can hardly wait to go back and have another look — as well as to see more of Mardi Gras again. Besides, I still need a picture of Richard Browning.

BJ Sweeping builds reputation for quality.

...continued from p. 33

“I also try to have the same operators run the same sweeper, so they become familiar with that exact unit. And I let them know what they can expect from certain engines, what to be careful about,” he says. “I tell them how to fix it, so they can explain it to me on the phone about the problems they have, and I can tell them how to fix most breakdowns so they can at least get through the night.”

Jones makes it a point to become familiar with each new sweeper he purchases by running it himself first. Then he often uses the newer truck for his back-up. “When I pay a sweeper off, I don’t trade it in. A lot of people do trade in their machines, but I’ve found that if you take care of your equipment, you can keep it a long time.”

Jones also advocates keeping extra parts — even engines — for emergencies.

“If I have an engine go out, I can have it repaired in a couple of days. Good preventive maintenance, and stocking standard wear and critical parts, is a key to staying aloft.”

Jones says he is very happy with his Schwarze equipment, and the support from Rickey Wyatt, who for a number of years has been his salesperson there. “Their sweepers have been doing the job for me,” he said. “I can easily work on the sweeper myself. For example, Schwarze sweepers are built so that if a hydraulic line breaks, I can just take that line loose, put on another one and keep on going. I don’t have to run all over, or wait, to find parts.”

His advice for new sweeper businesses? “Build a reputation on giving good service for a reasonable price. Learning to bid is the toughest part when you’re just starting out. There are a few accounts that I bid too low, but I still gave them the same quality. After awhile, I talked to the property managers and told them I needed to raise prices. Because I had done a good job, they were always happy to keep me at the higher price.”

Providing top service, training employees, and knowing his equipment — BJ Sweeping Service is an industry success because Bobby Jones does business the old-fashioned way.

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Port of Seattle

Sweeping Study

...continued from p. 19

what a wet vault really does. I think we’ve done a good job of proving what an EnviroWell technology sweeper will do, but there doesn’t seem to be as much data on wet vaults. Problem number two is that WDOE is still concerned about other contaminant-type issues that are normally considered for BMFs, such as oil and grease removal. The Port didn’t feel these were appropriate. The WDOE now indicates it may want us to expand our investigation to include these other pollutants. We’re talking through the issues right now.”

Ranahashi and Associates is located in Tigard, Oregon. You may reach Roger Sutherland by calling 503-968-1605.
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Notes on the National Scene

American Heritage Rivers Initiative — Restoring America's Majestic River Systems

Criteria for selecting the first "American Heritage Rivers" have been announced, following a series of 12 meetings across the nation. Hundreds of people participated in developing the guidelines that will be used to implement President Clinton's State of the Union vow to "designate 10 American Heritage Rivers [and] to help the communities alongside them revitalize their waterfronts and clean up pollution."

Through the American Heritage Rivers Initiative (AHRI), communities will nominate rivers for the designation. President Clinton will then select 10 of the nominees and a task force will work with each community to identify technical and funding needs. Though only a few rivers will be designated the first year, all communities that nominate sites will benefit from project-related workshops and other information tailored to their needs.

A federal liaison will be appointed to work with the communities whose rivers are selected. The liaison will help the community access existing federal services.

River Communities Charged with Nominating Rivers

Meetings held in various cities during April and May resulted in an abundance of ideas for the program and an early consensus: namely, that the rivers should symbolize America's traditional water heritage and represent a variety of stream sizes and surrounding land uses. They embrace a wide range of values, including strong community support, a vision of the river's historic and

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All issues of News-Notes are accessible on the NPS Information Exchange on EPA's World Wide Web Site: http://www.epa.gov. See page 26 for log-on information.
Survey Taps Volunteer Monitors

(Adapted from Watch Over Washington Survey Report (October 1996). Responses to his survey came from 156 groups representing over 11,500 people.)

Volunteer profile

- 1,567 volunteers monitor some aspect of water — surface or groundwater, quality or quantity, lakes, streams and rivers, or estuaries
- 6,258 monitor benthic macroinvertebrates;
- 6,120 monitor vegetation;
- 6,620 monitor wildlife;
- 2,106 monitor wetlands;
- 6,314 monitor things such as weather, land use, sediment, anxious construction sites. (Most monitor more than one resource.)

Over half the volunteers are school age; the rest are members of neighborhood associations or the general public. Of the student monitors, 21% are elementary students, 22% attend middle school, 40% are high school students, and 17% are college or graduate students.

Many classrooms are affiliated with GREEN (Global Rivers Environmental Education Network), NatureScaping, or Adopt-A-Stream; many community groups were trained by Adopt-A-Stream.

The average number of years these groups have been in operation is 4.9. Nearly two-thirds use email.

How credible is their work?

5,465 monitors collect data at Level Two on the matrix; 2,317 at Level One; 1,894 at Level Three.

Why do they monitor?

61% education/awareness; 21% to collect baseline data, and the rest checked: various reasons — red flag/early warning, enforcement/compliance, research, a specific project, or land use impact.

Using the matrix will "facilitate broader, more consistent monitoring," said Phillips. It was also the first step, she says, in achieving recognition by agency scientists. "It was kind of a bargain. If the volunteer group is willing to work this hard, we will look at their data for these purposes. But if they only want to go this far, we will only look at it for this purpose."

The matrix has gone a long way toward convincing skeptics that volunteer monitoring can go beyond outreach. Some are even acknowledging that the very highest quality volunteer data could be used for 305(b) reports and the state's 303(d) list, if certain requirements are met.

Washington's volunteers seem more than ready to accept the challenge. Three-quarters of the volunteer coordinators surveyed would like their groups to receive training, and half want to monitor additional resources or parameters. "Our survey showed most volunteers are eager to meet high standards. We want to help the volunteers develop skill levels which will support their needs," said Phillips.

To accommodate the widespread enthusiasm for volunteer monitoring, Ecology is linking volunteers through "Watch Over Washington," or WOW. Using a Web site (http://www.wa.gov/ecology/wq/wow.html) as a virtual central meeting place, volunteer members can locate monitoring activities in their areas and access training opportunities. Coordinators of monitoring groups can keep abreast of what other groups are doing and contact each other to combine resources. They can also learn about, and announce, events, resources, tools, new methods, environmental reports, and success stories on the Web site. There will also be a section, or FAQ, as it is called, for frequently asked questions about monitoring.

Support for such a citizen monitoring network is overwhelming. Almost three-quarters of the volunteers surveyed indicate that they are very interested in participating. Although new and still fairly informal, a number of contacts have already occurred via the network's roster of members organized by watershed. Phillips is active as a catalyst as well. She explained, "When I learn of a project starting up, I tell them about other projects in the area that might act as mentors or partners. For instance, I recently put two college instructors in the Puylup River watershed in contact with each other. One was hoping to start up a monitoring program; the other had already established his. I thought they might share equipment and lab services."

[For more information, contact Annie Phillips, Environmental Education Specialist, Washington State Department of Ecology, P.O. Box 47800, Olympia, WA 98504-7800. Phone: (360) 407-0496; fax (360) 407-6874; email: apd481@cywa.wa.gov. Or contact Beverly Japsen, Special Assistant, Governor's Council on Environmental Education, P.O. Box 40000, Olympia, WA 98504-0000. Phone: (360) 407-7217; email: beverly@parks.wa.gov.]

20 NONPOINT SOURCE NEWS-NOTES AUGUST/SEPTEMBER 1997, ISSUE 49
Washington Volunteer Monitors Aspire to Better Data

No one knows exactly how many volunteer monitors there are in the United States (the last official count, in 1993-1994, tallied over 340,000), but Washington state has newly 160 groups with 8,000 volunteer monitoring water alone. All this activity generates a lot of data — and a potential nightmare for quality assurance.

A 1996 survey of the state’s volunteer monitors revealed that most are eager to have their data used by state and local agencies, but according to Annie Phillips, a Washington Department of Ecology environmental education specialist, "Different groups use different methods, standards, and levels of quality." This disparity can make it difficult for agencies to use data from volunteers.

The survey, conducted by the Department of Ecology (Ecology) and the Governor's Council on Environmental Education, produced a statewide list of the location of monitoring projects, the parameters measured, and the methods and quality assurance protocols used by the monitors. "It became clear that each of the varying groups did things their own way and therefore, their data were inconsistent and of unknown quality," Phillips said.

To solve this problem, Ecology developed a matrix to characterize the methods and quality of the data collected by volunteers. The agency categorizes data from each volunteer monitoring group according to criteria such as quality assurance/quality control protocols, monitoring methods, and the education and training of the monitors. "We developed the matrix as a kind of ranking system to give a standard description for the quality of data produced for a specific project," explained Phillips.

<table>
<thead>
<tr>
<th>Level</th>
<th>Quality Assurance/Control (QA/QC) Protocols</th>
<th>Examples of Activities</th>
<th>Desired Education/Training</th>
<th>General Uses of Data by Ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td>One</td>
<td>No formal QA/QC plan required</td>
<td>General field observations, including the number and diversity of organisms</td>
<td>Volunteer or student with brief orientation</td>
<td>Educational, general awareness</td>
</tr>
<tr>
<td>Two</td>
<td>Basic written plan - purpose, parameters, methods, sites, schedule</td>
<td>Field sampling; analysis using field kits; observing categorical abundance*** of organisms and identifying them to the order level</td>
<td>Volunteer, student or technician supervised by an expert monitor</td>
<td>Educational; watershed characterization; red flag or early warning</td>
</tr>
<tr>
<td>Three</td>
<td>Formal QA plan (i.e. meets 24 requirements of EPA’s new Vol. Mgmt. Guide to QAPP, 1996); all tests performed by lab</td>
<td>Using calibrated meters for field measurements or following the protocols in a current APHA Standard Methods; collecting and analyzing water samples; identifying benthos to the family level; volunteer portion of Ecology’s lake water quality assessments</td>
<td>Trained volunteer (e.g., Streamkeepers); technician with experience or training in an established volunteer monitoring program</td>
<td>Screening level information; scoping phase of watershed approach; 303(b) Report; Best Management Practices (BMP) evaluation data; water quantity/flow data</td>
</tr>
<tr>
<td>Four</td>
<td>Follows formal QA plan and documents exactly how it is implemented; sample chain of custody</td>
<td>Toxic substance sampling; sampling for enforcement purposes; biomass; identifying benthos to the genus/species level</td>
<td>Professional/Qualified, individual with degree and specific training or equivalent experience</td>
<td>Baseline, impact and ambient assessments; action planning/ policy development; permitting/compliance/enforcement; 303(d) List***</td>
</tr>
</tbody>
</table>

*Ecology’s 200x® Report sheet, although not intended for beneficial use such as streamlining and fishing – or whether these uses are improved. Contributions of data are selected from varous sources, but must meet high standards (see Level 1).

**Ecology’s 303x® List shows improved and threatened waters that don’t or probably couldn’t meet applicable water quality standards. Ecology accepts data for this list from outside sources, but it must meet the highest professional standards (see Level 4). Both are published every two years.

AUGUST/SEPTEMBER 1997, ISSUE 44
NONPOINT SOURCE NEWS-NOTES 19
Water Quality Monitoring Report
May 1996 – 1997
Ala Wai Canal Watershed Project, DOH
# Water Quality Monitoring and Assessment

## Water Quality Monitoring Report - May 1996-97
Ala Wai Canal Watershed Project

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Prepared by:
Clean Water Branch
Department of Health
December 1997
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EXECUTIVE SUMMARY

The report describes nonpoint source pollution that is consistent with its diverse and widely dispersed (diffused) characteristics which add to the complexity of the problem. It emphasizes the importance of source-specific and event-triggered pollutants having a direct impact on human health and, in most part, the overall cause of water quality impairment and degradation of the Ala Wai Canal. In essence, the status of water quality in the Ala Wai Canal is clearly a condition attributed to the watershed from which pollutants originate.

Nitrogen levels in the Ala Wai Canal exceed the Standard more than 97 percent of the time in the area between the Manoa/Palolo Stream outlet and the Kapiolani Library end. Similarly, phosphorus levels exceed the mean concentration more than 87 percent of the time. Instream nitrogen levels in the Ala Wai Canal watershed exceed the Standards in all segments of the criteria applicable to streams in Hawaii. Also, phosphorus concentrations in the Makiki watershed are consistently high for ambient (normal flow) levels and during a storm event sampling. A comparison of instream phosphorus concentrations indicates that phosphorus in the Makiki watershed is significantly greater than the levels found in Manoa and Palolo watersheds.

Investigations in the past have noted increased phosphorus loadings with urbanization, particularly with large percentages of commercial and multiple-family housing, and it may not be surprising at all to expect higher levels of phosphorus in the lower Makiki watershed, as well. The close relationship between phosphorus and total suspended solids in the Makiki watershed and the high urban density may account for the levels found by the survey. The findings also reemphasize the importance of erosion-controlled, construction site BMPs, impermeable surfaces, forest management practices, ground cover, urban storm drain, etc., in controlling runoff as well as phosphorus loadings in receiving waters.
INTRODUCTION

It is widely known that storm events have a significant impact on water quality impairment. Polluted runoff from land is the primary cause of water pollution in our streams and coastal waters. Nutrients, toxic materials, suspended and particulate matter are major concerns that have a major influence on the alteration and degradation of water quality, as well as on the physical and biological habitat. Such impairment causes water quality standards violation and can result in the beneficial use of the resource. Polluted runoff problems are the result of activities that take place in the watershed, which is the focus of this project. The monitoring project is currently ongoing and is part of a larger, targeted watershed approach in addressing nonpoint source pollution issues and problems.

The report presents the findings and results of water-quality monitoring of three major streams in the watershed: the Manoa, Makiki and Paliolo streams. The discussion on water quality is presented with particular reference to the high levels of bacteria, inorganic and nutrients observed during the aftermath of a specific storm event in the Manoa-Paliolo watershed. Water-quality issues have shown high levels of pollutants that suggest the presence of sources that may have a direct role in the degradation of surface-water quality and waters of the Alakai Wai Canal.

The Alakai Wai Canal is known to be heavily dependent on sediment, as well. After moderate rain storms, muddy water and the accumulation of trash and debris transform the canal into a bleak that often lasts for at least two or more days. Both natural erosion from forested areas and human activities (construction projects) contribute to these problems. Other pollutants of concern, that are not as apparent but are just as important, include bacteria/viruses (pathogens), automobile lubricants, toxic metals and pesticides as a result of surface runoff from streets and highways, parking
BACKGROUND
Nonpoint source pollution is often contrasted with point source pollution as a discharge of pollutants originating from a diffuse source as compared to the latter originating from a discrete source (note: storm drain outlets are considered point source). Although the distinction between the two major categories of pollution may be clear, the methods of treatment and control of nonpoint source are vastly more complex due to their nature and origin of pollutants. To further complicate matters, the magnitude and potential risk of background pollution in the urban setting are often ignored or unrecognized as pollutants originate and accumulate in early (pre-event) stages prior to surface runoff events. During such events, pollutants wash through storm drains and eventually appear in surface waters where it turns into an axial plane of mostly water combined with an accumulation of litter and debris. However, other pollutants such as bacteria and virus occur and are invariably underestimates by traditional (influent) monitoring, unless the effort is targeted to both events-triggered monitoring and source-specific identification of pathogens. (In this experience, exceptionally high numbers of indicator bacteria, Clostridium perfringens, during rainfall events suggest the presence of fecal contamination. An investigative approach was then initiated as a practical alternative.) Also, the historic data on water quality not only showed high levels of nutrients, but a consequence phosphatization blooms have severely reduced water clarity of the canal. In essence, the status of water quality in the Ala Wai Canal is clearly a condition attributed to the watershed from which pollutants originate.

As with other watersheds in the state, the Department has started a watershed approach to assessing nonpoint source pollution. Between other community outreach programs and in conjunction with governmental agencies, water quality monitoring is included as part of an integrated effort to accomplish watershed protection and management goals of the State. This project is part of a support activity to the Department of Health’s (DOH) watershed protection initiatives, e.g., Ala Wai Canal Watershed Improvement Projects.

Water quality sampling stations were established at three major streams, Makiki, Manoa and Pahoa streams, of which the latter two have the largest flows. Water sampling started in May 1990 and is currently ongoing. The results of this are shown on the attached maps (Figure 1). Grab samples of water from six stations were routinely checked on a weekly basis for pH, temperature, dissolved oxygen, and conductivity. Salinity was included where tidal influence was noted. The nutrients tested twice per month included particulate nitrogen, nitrate-nitrite nitrogen, ammonia nitrogen, potassium nitrate, phosphate and orthophosphate. Chlorophyll a, turbidity and total suspended solids (TSS) analyses were also included at the same (two times) nutrient sampling.

Field measurements of the physical parameters were taken in situ with the use of a Hydrolab Data Sandell multi-parameter probe. Water samples for nitrogen, chlorophyll a, and TSS were collected in plastic containers kept chilled in storage prior to transport to the DOH Laboratory.

RESULTS

Ala Wai Canal - Vypolyte Library End, May Day Street Mouth and Ala Moana St. Bridge.

Water quality requirements in the canal is most severe at the Diamond Head end which is approximately two miles from the mouth of the canal. The average water depth is about five feet with very poor water exchange. Near, located at this site is a major drainage culvert that discharged polluted runoff from the Kaimuki-Alepihi and parts of Diamond Head business and residential districts.

Nutrient levels progressively decline from the Diamond Head end to the Ala Moana Bridge toward the Ala Wai Yacht Harbor. The results of mean daily concentrations of total nitrogen and total phosphorus observed in the Ala Wai Canal are shown in Table 2. Contrary to the general trend, however, there is a slight increase in phosphorus at the Ala Moana Bridge site. Of particular note...
in the additional input of nutrients from Makii Stream which is located approximately 0.4 miles upstream of the Ala Moana Bridge site.

<table>
<thead>
<tr>
<th>Location</th>
<th>Total Nitrogen mg/l</th>
<th>TotalPhosphorus mg/l</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kayakua Estuary</td>
<td>0.150</td>
<td>0.014</td>
</tr>
<tr>
<td>Manoa Stream</td>
<td>0.090</td>
<td>0.0125</td>
</tr>
<tr>
<td>Ala Moana Bridge</td>
<td>0.175</td>
<td>0.010</td>
</tr>
</tbody>
</table>

Total nitrogen concentrations in the area exceeded the State Water Quality Standards (Standard) by nearly six-fold and total phosphorus by nearly six-fold the amount of the Standard.

The exceedance frequency distributions of nutrient levels are used to predict violations in water quality standards. The values applicable to measures are compared with the projected frequency at the geometric mean concentration and at the 2 percent level (Table 3).

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Frequency</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Nitrogen</td>
<td>0.75</td>
<td>0.47</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>0.85</td>
<td>0.59</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>0.75</td>
<td>0.47</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>0.85</td>
<td>0.59</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>0.75</td>
<td>0.47</td>
</tr>
<tr>
<td>Total Phosphorus</td>
<td>0.85</td>
<td>0.59</td>
</tr>
</tbody>
</table>

In summary, the conditions of the stream were in compliance with the criteria applicable to streams in Hawaii as shown in Table 4. Phosphorus concentrations have been noted to be exceptionally high for streams (normal low flow) levels and during the rain season. With regards to water clarity and particulate matter, respectively, mean turbidity shows compliance part of the time, however, non-compliance of total suspended solids (TSS) occurs most of the time.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Frequency</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSS</td>
<td>0.75</td>
<td>0.47</td>
</tr>
<tr>
<td>TSS</td>
<td>0.75</td>
<td>0.47</td>
</tr>
<tr>
<td>TSS</td>
<td>0.75</td>
<td>0.47</td>
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<tr>
<td>TSS</td>
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<td>0.47</td>
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<tr>
<td>TSS</td>
<td>0.75</td>
<td>0.47</td>
</tr>
<tr>
<td>TSS</td>
<td>0.75</td>
<td>0.47</td>
</tr>
</tbody>
</table>

Note: TSS, Total Suspended Solids; "Yes" = in compliance; "No" = not in compliance.
Midah Stream - Wet versus Dry Period

The wet period samples taken from November 1 through April 30 and were compared with samples taken during the dry period from May 1 through October 31. The results are shown in Table 5. The data show significant differences in water quality during wet and dry periods. Only nitrate-nitrogen and TSS levels indicated significant differences between the two periods with higher levels during the wet period. The non-parametric procedure, Mann-Whitney Rank Sum Test, was used to determine the differences between the observed levels.

Table 5. Ambient Water Quality Comparisons Between Wet and Dry Periods in Midah Watershed

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Wet Period</th>
<th>Dry Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrate-Nitrogen</td>
<td>0.02 mg/L</td>
<td>0.07 mg/L</td>
</tr>
<tr>
<td>Total P - orthophos</td>
<td>0.1 mg/L</td>
<td>0.07 mg/L</td>
</tr>
<tr>
<td>TSS</td>
<td>5.4 mg/L</td>
<td>1.5 mg/L</td>
</tr>
</tbody>
</table>

It is interesting to note that TSS is greater during the dry rather than the wet period, in contrast to nitrate-nitrogen levels that show an increase during the wet period. Monitoring over a longer period may be necessary to make any definitive conclusions in this area.

Figure 2. Daily Rainfall for March 1997 in Upper Manoa Watershed
However, as shown previously in Table 3, phosphorus levels show a marked increase (12.875 mg/L) in 10 percent of the samples taken at the Ata-Wai Canal, which was the only significant increase in phosphorus observed near the Ata-Wai Canal. A similar observation was made by Lewis et al., (1992) in their water quality study of the Ata-Wai Canal, during which a significant increase in phosphorus was shown after rainfall in samples taken near the Malaki Stream.

The monitoring results observed by the CCH in their storm water monitoring of Manoa

![Graph showing output of total phosphorus after single storm event](image)

**Figure 3. Data Source: Dept of Public Works City & County of Honolulu**

Malaki Stream may explain the reason for the increase in phosphorus from the Malaki Stream shown in Figure 3, which is a substantial increase over the baseline event. The plotted result from a single storm event is compared with that of the baseline event at King Street sampling site. During this event, the compound baseline level of phosphorus in Palihi and Manoa Streams remained at only 0.02 mg/L. By comparison, the concentration of phosphorus from Malaki Stream during the storm event was nearly nine times greater than the levels observed at Palihi and Manoa Streams combined. Although by far from showing a complete profile of the discharge quantity, the bar graph in general illustrates the impact from a single storm event and possibly gives a clue to the elevated levels of phosphorus found at the lower end of the canal. There is further evidence suggested by the survey results that show elevated ambient levels of phosphorus in Malaki Stream.

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Samples</th>
<th>Mean TSS</th>
<th>Mann vs. Wilcoxon</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ata-Wai Canal (A)</td>
<td>10/25</td>
<td>0.538</td>
<td>NA vs. TA</td>
<td>Yes</td>
</tr>
<tr>
<td>Manoa &amp; Palihi (A)</td>
<td>10/21</td>
<td>0.578</td>
<td>NA vs. NA</td>
<td>Yes</td>
</tr>
<tr>
<td>Malaki Watershed (M)</td>
<td>10/21</td>
<td>0.179</td>
<td>NA vs. NA</td>
<td>No</td>
</tr>
</tbody>
</table>

A comparison of mean phosphorus concentrations from the Malaki, Manoa and Palihi watersheds is shown in Table 4 and also in Figure 4. The median concentration of phosphorus in the Malaki watershed is significantly greater than the levels found in Manoa and Palihi watersheds. The source for the high concentrations in polluted runoff from the Malaki watershed is yet unknown, however.

The survey results show no significant difference between levels of phosphorus found in Palihi and Manoa watersheds. Also, no difference in median concentrations of TSS and turbidity appear in each

![Graph showing comparison of total phosphorus concentrations in Manoa, Manoa and Palihi](image)

**Figure 4. Data Source: Dept of Public Works City & County of Honolulu**

*Note: The data for the comparison of total phosphorus concentrations in Manoa, Manoa and Palihi watersheds is shown in Figure 4. The median concentration of phosphorus in the Malaki watershed is significantly greater than the levels found in Manoa and Palihi watersheds. The source for the high concentrations in polluted runoff from the Malaki watershed is yet unknown, however.*
watershed. The Kruskal-Wallis one way analysis of variance on ranks and a pairwise multiple comparison procedure (Dun’s method) was used in the statistical analysis.

**Association between Total Phosphorus and TSS**

Although the data reflect concentrations of grab rather than flow-weighted samples, the results appear to show an association between phosphorus and particulate matter (TSS) transported by storm water runoff. Load runoff relationships similar to this have been shown in the past by Bedout, et al. (1980). The following chart (Figure 5) shows the relationship of phosphorus and total suspended solids in the Makiki watershed. Phosphate loadings are known to increase with urbanisation, particularly with large percentages of commercial and multiple-family housing (Cohen, 1974; Neil, 1979; Whipple, et al., 1974; Whipple, 1978). It may not be surprising at all to expect higher levels of surface runoff pollutants, e.g., phosphorus, in the lower Makiki watershed, considering the urban density, extent of impervious areas and drainage network. These findings reemphasize the importance of erosion control, construction site BMPs, impervious surfaces, storm water management practices, ground cover, urban street dust, etc., and related runoff control measures that can result in controlling nutrients in receiving waters, as well.

The effectiveness of BMPs can be measured by monitoring phosphorus in receiving waters in combination with documentation of environmental "indicators" on land. Although detail

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![Figure 5. Relationship between Total Suspended Solids and Total Phosphorus in Makiki Stream](image-url)

---

**Table 7. Total Nitrogen (mg/L) Concentrations in Major Watersheds, May 1985 through June 1987**

<table>
<thead>
<tr>
<th>Watershed</th>
<th>Mean</th>
<th>Lower 25%</th>
<th>Upper 75%</th>
<th>Comparison (p-value)</th>
<th>Confidence (p-value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Makiki Watershed (P)</td>
<td>0.090</td>
<td>0.056</td>
<td>0.134</td>
<td>0.129 vs. Ms</td>
<td>Yes</td>
</tr>
<tr>
<td>Mauna Watershed (M)</td>
<td>0.290</td>
<td>0.129</td>
<td>0.480</td>
<td>0.290 vs. Ms</td>
<td>Yes</td>
</tr>
<tr>
<td>Makiki Watershed (M)</td>
<td>0.085</td>
<td>0.038</td>
<td>0.160</td>
<td>0.085 vs. Ms</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Paloa Stream recorded the highest median concentration of nitrogen and followed by Makiki and Mauna Streams. However, the levels recorded during the single storm event, Makiki Stream showed an increase in nitrogen concentration (Figure 6), in marked contrast from ambient levels.
Although elevated levels of pollutants are expected as a result of surface runoff, the source of nutrients in the Malaki watershed is unknown. With respect to climatic conditions alone, it can be reasonably assumed that sources are readily subject to surface runoff as shown, and that the quantity of pollutant discharge is directly correlated to varying characteristics of rainfall. Under such conditions, nutrient concentrations in a given area will be influenced by such factors as soil type, rainfall, percolation, low-flow discharges, and other hydrologic characteristics. The investigation as to the source, cause and extent of pollutants is not yet completed.

Lower Manus Stream (where Paloilo Stream converges)

The lower Manus Stream sampling site is located approximately 100 feet above the confluence with Paloilo Stream (figure 7). The results of nitrogen, phosphorus, turbidity and TSS levels are compared with the standards at various levels of the criteria as shown in Table 8. Nitrogen levels observed at the Manus Stream site exceed the water quality standards during both wet and dry seasons.

### Table 8: Manus Stream Compliance with State Water Quality Standards

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dissolved N</th>
<th>% of Time</th>
<th>% of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Nili &amp; Nili</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Total P</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Turbidity</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: "X" means not in compliance from June 10 through October 10.

TSS and total phosphorus on the other hand meet the Standards in all cases. Turbidity levels meet the wet criteria, but exceed the dry criteria.

### Paloilo Stream

As noted previously, instream levels of nitrogen in the Paloilo watershed are markedly different from that of other watersheds, but in all cases the same parameters (nitrogen) invariably exceed the applicable Standards. If the levels of nutrients in the Paloilo and Malaki watersheds are closely examined, the results appear to show the significance of the two watersheds in terms of their nutrient concentrations. Nutrient management which leads to reduction in phosphorus (Malaki watershed) and nitrogen (Paloilo watershed) in the two watersheds can be prioritized due to the distinct nutrient concentrations.
Table 8. Fish and Stream Compliance with State Water Quality Standards

<table>
<thead>
<tr>
<th>Parameter</th>
<th>No</th>
<th>Dry</th>
<th>Wet</th>
<th>Mat</th>
<th>Day 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMDL (W)</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>TMDL (M)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>TMDL (M/N)</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>TMDL (D)</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Total</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: "No" indicates water body not sampled; "Yes" indicates water body sampled. "Dry" is in September through October only.

To implement a more manageable approach to nutrient management, the results suggest the use of parameter-specific TMDLs for each watershed rather than the use of a multiple parameter TMDL for the Ala Wai Canal. Nitrogen levels are not in compliance in all categories as shown in Table 9. Phosphorus and turbidity levels partially exceed the standards applicable to dry periods only.
The use of \( C. \) pseudotuberculosis is logical because it has been shown to survive in aquatic environments. It is not killed by high chlorine levels, and it is not destroyed by high temperatures. The use of this organism as an indicator of water quality is well established.

The results of the study indicate that the use of \( C. \) pseudotuberculosis as an indicator of water quality is effective. The use of this organism as an indicator of water quality is well established.

The results of the study indicate that the use of \( C. \) pseudotuberculosis as an indicator of water quality is effective.
distribution of \( C \) perchlorate is drawn across the chart, as shown by the broken and solid lines. The geometric mean for the Ala Wai Canal theoretically complies with the proposted standards at 50 CFU, the midpoint of the chart as noted. However, well above the proposed standards are levels that are extremely low and indicate levels that are below the detection limit. Thus, the illustration on the chart can be used to establish the water quality objective for achieving acceptable levels of bacteria for the Ala Wai Canal. \( C \) perchlorate detections greater than 90 CFU on the chart is considered to be levels significantly above the normally expected distribution, thereby suggesting the occurrence of contaminated levels.

With continued monitoring, the performance of each objective can be readily and objectively monitored by noting the changes in bacterial densities. The monitoring results illustrate how continuous objectives can be established for bacterial contamination in the Ala Wai Canal. Effective BMPs, enforcement actions, and other corrective measures to mitigate sewage contamination should result in reducing water quality to acceptable levels for water use as shown in the Ala Wai Canal.

Reference


Q  Stockpile Runoff Project
Chromium Leachate Exceeded Standards
Khal Spenser, UH.
Gregory E Granato, 08:19 AM 10/21/97, Asphalt as a source of pollutants

Return-Path: <khal@soest.hawaii.edu>
X-Sender: khal@akue.soest.hawaii.edu
Date: Tue, 21 Oct 1997 08:19:23 -1000
To: "Eugene P. Dashiel!" <dashiell@lava.net>
From: "Gregory E Granato, Hydrologist, Marlborough, MA <ggranato@usgs.gov> (by way of khal@soest.hawaii.edu (Khalil J. Spencer))
Subject: Asphalt as a source of pollutants


is a good ref.
Also:

MN DOT did a report that may be helpful:


Abstract

The Stockpile Runoff Project addressed environmental concerns regarding the quality of runoff water from salvaged pavement stockpiles. Three experimental stockpiles were studied, one pile consisted of coarse concrete, a second consisted of fine concrete material, and the third consisted of salvaged bituminous material (recycled asphalt product) obtained from a pavement milling project.

The leachate water from piles flowed through a sampling flow monitoring system with data loggers and automated sequence samplers. Composite water samples were analyzed using EPA approved methods and quality control protocols. Comparing the observed median values for the stockpile runoff with Minnesota standards for surface waters, the pH exceeded and chromium may have exceeded the standards. Although there is sediment and leachates emanating from stockpiles, the long-term concern reduces to suspended and dissolved solids, and pH. Polynuclear aromatic hydrocarbons (PAH) concentrations from the bituminous millings pile were near or below detectable limits.

Ramping for stockpile storage sites should include management practices of controlling runoff similar to those that are used for construction sites. Berms, straw bales, grass or other filter channels, and localized stockpile sites some distance from surface waters may be appropriate practices. Possible impacts on the ground water system should be considered.

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The PAH values may have been affected by sampling materials (PVC plastic) and by the fact that the sampling system had several open channel waterfalls in the flow train.

Printed for "Eugene P. Dashiel!" <dashiell@lava.net>
For information about highway runoff please consult our web pages:

http://wwwvarea.wr.usgs.gov/owv/hwrw/

under water quality. The pages are still a work in progress, input would be appreciated.

Opinions are my own & do not reflect those of the USGS or the Federal govt.

~~~~~~~~~~~~~~~~~~~~~~~~~~~~
Gregory E. Granato
Hydrologist
U.S. Geological Survey, MA-RI District
28 Lord Rd, Suite 280
Marlborough, MA 01752
phone 508 490 5055
fax 508 490 5068
R  Trapping Metals in Stormwater from Highway Runoff.
University of Cincinnati researchers devise system to "trap" metals in storm water from highway runoff.

OHIO A new system to trap dangerous pollutants in highway storm water runoff has been developed by researchers at the University of Cincinnati College of Engineering. This system was tested last fall along Ohio's second busiest stretch of interstate highway.

Doctoral candidate John Sansalone developed the system to reduce the amount of toxic metals that wash into our streams from highways. Sansalone is now testing the partial exfiltration trench (PET) system under the guidance of Steven Bachinger, a University of Cincinnati associate professor in civil and environmental engineering.

PET is a modification to existing highway drainage technology, easy to install and relatively inexpensive. There are two main components of the system. The first component is a bed of oxalate-coated sand that attracts and holds heavy metals in the storm runoff.

Laboratory experiments have shown that concentrations of pollutants such as lead, cadmium, copper and zinc are dramatically reduced by this sand. The second part of the system is a layer of porous pavement concrete block, which prevents the movement of solids. "The system is a very effective trap for solids that are washed off the highway," says Sansalone. "Solids are stopped right at the surface of the porous pavement. They can accumulate there, and as part of routine maintenance, they can be vacuumed back off the surface."

The concrete also neutralizes acidic rainwater and actually raises the pH of the water to the level where the sand layer works best.

Laboratory tests of the system indicate PET can virtually eliminate lead, cadmium, lead and zinc from storm water for up to 16 years. PET has been shown to be effective even in severe storms.

The system was field tested in the fall of 1996 to determine if real-world results match the laboratory results. The researchers must monitor the system for several months to see how well it survives under the freeze-thaw cycle of winter and spring, and to see how road salt and other detox chemicals affect it. The field testing continues.
University of Cincinnati Environmental Engineers Demonstrate Effective Method For Reducing Pollution From Highway Runoff

Sept. 29, 1997
Contact: Chris Curran
(513) 556-1806 (O)
chris.curran@uc.edu

Cincinnati -- Researchers in the University of Cincinnati College of Engineering have shown that a modified filtration system along interstate highways can prevent heavy metals from polluting nearby water supplies.

The system, known as a partial exfiltration trench (PET), was designed and built by research assistant professor John Sansalone as part of his doctoral research in the department of civil and environmental engineering at UC. The PET replaces the normal sand used in highway storm drainage systems with an iron oxide coated sand. That makes the sand significantly more effective at trapping heavy metals such as cadmium, copper, lead and zinc.

"Polluted water flows in, and clean water flows out," explained Steven Buchberger, associate professor of environmental engineering and Sansalone's thesis adviser.

Sansalone presented data from a year-long field test during the recent World Congress of the International Association for Hydraulic Research (IAHR) in San Francisco. A prototype PET system was installed along a stretch of Interstate 75 near downtown Cincinnati. It is the second busiest stretch of interstate highway in the state of Ohio.

The effectiveness of the PET system varied for each specific metal, but the overall trapping efficiencies ranged from 82 to 97 percent. The PET even holds up well during heavy rainstorms. The system can handle up to one inch of rain per hour. That's when Sansalone discovered a side benefit to his novel system.

"The PET not only works as a water quality device, but it can act like a water quantity control device to reduce surface flooding," said Sansalone. That discovery was completely unexpected in the Cincinnati area where clay soils are common.

Sansalone will continue his research by looking at ways to make the system more economical and efficient. It took ten tons of coated sand to treat 20 meters of highway during the field test, so Sansalone must find a consistent and simple method for producing huge quantities of coated sand.

"When we made the prototype, we made more coated sand than has ever been artificially produced on Earth. It was a real undertaking," said Sansalone.

He will also work on modifying the coating itself to increase its trapping efficiency and lifetime. The goal is to have a system which can last as long as the typical highway pavement about 15 years. Lab tests indicated Sansalone's coating could last approximately 40 years. The field tests indicated a much shorter life expectancy, but one very close to the final project goal.

"Conditions in the field are always more severe than you can simulate in the lab," said Sansalone. "Based on the results we've seen so far, a 10 to 15 year life is reasonable."

http://www.uc.edu/www/info-services/stormh2o.htm

10/17/97
"Our laboratory work has shown great promise for what we intend to do in the field with this prototype PET installation. We think the system, by the nature of its design, is cost effective. It is not a new component for urban highways. It is essentially an upgrade."

But it will take more than one storm to determine how well the PET prototype works in the real world. The researchers must monitor the system for several months to see how it holds up under the freeze-thaw cycles of winter and spring and to see how road salt and other de-icing chemicals affect it.

The research is funded by the Ohio Department of Transportation.

-30-

echris.curran@uc.edu
Research News Releases
Public Relations Home Page
University of Cincinnati Home Page

http://www.uc.edu/www/info-services/runoff.htm

10/17/97
University of Cincinnati Engineers Field Test New System
To Trap Heavy Metals in Stormwater Runoff

Contact: Chris Curran
(513) 556-1806 (O)
chris.curran@uc.edu

Cincinnati -- Researchers in the University of Cincinnati College of Engineering have designed a new system to trap dangerous pollutants in highway stormwater runoff. The system is being field tested this fall along the second busiest stretch of interstate in Ohio.

Doctoral candidate John Sansalone developed the new system. Sansalone's adviser is Steven Buchberger, associate professor in civil and environmental engineering at UC. Sansalone calls the system "PET" for partial exfiltration trench. It's a modification of the current systems used to improve drainage under highways, so it's expected to be easy to install and relatively inexpensive.

There are two key components to the system. The first is a bed of oxide-coated sand which attracts and holds onto heavy metals in the storm runoff. Lab-scale experiments demonstrated the special sand can dramatically reduce the concentrations of pollutants such as lead, cadmium, copper and zinc. This component takes care of the dissolved metals.

The second part of the system, a layer of porous pavement concrete block, acts as a giant strainer. "The system is a very effective trap for solids that are washed off the highway," said Sansalone.

"Solids are stopped right at the surface of the porous pavement. They can accumulate there, and as a part of routine maintenance, they can be vacuumed back off the surface."

The concrete also neutralizes acidic rainwater and actually raises the pH to the level where the sand layer works best.

Sansalone has spent the last year testing a laboratory version of the PET system. Experimental results reported at the Seventh International Conference on Urban Stormwater Drainage in Germany this month indicate that the system can virtually eliminate nickel, cadmium, lead and zinc from stormwater runoff for up to ten years. And it doesn't matter how bad the storm is.

"Everything was based on peak flows or the heaviest flows, and we're still getting good results," said Sansalone.

The PET system is being installed along I-75 in a heavily traveled and industrial section of Cincinnati. The UC researchers have been trapping rainwater along that stretch of highway for the last two years to determine exactly what pollutants are present. Those same stormwater samples were used to test the lab-scale PET system, so the researchers expect the field-scale model will work effectively and inexpensively.

http://www.uc.edu/www/info-services/runoff.htm

10/17/97
Even more important than lifespan is the ability to clean or recharge the PET system easily. In the next phase of the project, Sansalone will try to demonstrate that the trapped metals can be removed by a simple back-washing. That's important, because if you can't remove the toxic pollutants for disposal, you wind up with tons and tons of toxic waste.

Lab-scale experiments indicate the back-washing process is feasible. However, field tests are required to test the procedures on a large-scale operation.

Sansalone's research is funded by the Ohio Department of Transportation and the National Science Foundation. His presentation in San Francisco was recognized by the IAHR's John F. Kennedy Award for Hydraulic Research. The award is named for an engineering researcher who specialized in hydraulics.

chris.curran@uc.edu
Research News Releases
Public Relations Home Page
University of Cincinnati Home Page

http://www.uc.edu/www/info-services/stormh2o.htm

10/17/97
Metal Removal from Stormwater in Street Storm Drain Catch Basins
Fossil Filter Company, Manufacturer
DATE:  9/12  
TO:  Gene Davis  
FAX NO: (803) 593-5336  
COMPANY:  
FROM:  Kristar Enterprises  
RE:  

PAGES  (enc. cover)  
IF YOU ARE MISSING ANY PAGES OF THIS FAX PLEASE CONTACT ME AT THE NUMBER ABOVE  

Here is the Fossil Filter information you requested. If you have any questions please call 1-800-579-8879  

Thanks  

POLLUTION from stormwater runoff??? Fossil Filter is the SOLUTION!!!
1) **WHAT IS FOSSIL FILTER™?**

Fossil Filter™ (patent pending) is a trough apparatus, installed in surface water drainage inlets, that incorporates EPA-approved adsorbents which collect petroleum hydrocarbons and other contaminants while permitting the unimpeded passage of water. Units are available to fit square, rectangular, round and single-sided (curb-type or trench drain) inlets and can be used in new or post-construction projects. Fossil Filter™ is a product of KrisStar Enterprises, Inc. of Santa Rosa, California.

2) **HOW DOES FOSSIL FILTER™ WORK?**

Regarding the removal of petroleum hydrocarbons, all versions of the Fossil Filter™ function as follows: As the surface water flows into the inlet, it passes through the Fossil Filter™ where the installed adsorbent material removes petroleum-based contaminants. The Fossil Filter™ with Silt Basin has the added capability of removing "heavy metals." The Fossil Rock™ adsorbent material used in Fossil Filter™ removes contaminants from the water through a process called "adsorption" (acts like a magnet) rather than "absorption" (acts like a sponge).

3) **WHAT MATERIALS ARE USED IN THE MAKING OF FOSSIL FILTER™?**

All components for the square, rectangular and curb-type models of Fossil Filter™ are of galvanized steel. The round units and Fossil Filter™ with Silt Basin are of fiberglass. (See #4 for a discussion on the incorporated adsorbent media.)

4) **WHAT ARE THE MOST APPROPRIATE USES OF FOSSIL FILTER™?**

The use of Fossil Filter™ is most appropriate where motor vehicled park, are reflected or are served. Customer and employee parking lots and corporation yards are excellent prospects for the installation of Fossil Filter™.

5) **WILL THE USE OF FOSSIL FILTER™ SATISFY CURRENT FEDERAL EPA NPDGS CRITERIA? CAN FOSSIL FILTER™ BE INCLUDED AS A COMPONENT OF A COMMUNITY’S SWPPP (STORMWATER POLLUTION PREVENTION PROGRAM)?**

The federal EPA's NPDPS program, designed to control the discharge of pollutants to waters of the United States, cites a definition of oil/water separator as "A device installed, usually at the entrance to a drain, which removes oil and grease from water flows entering the drain." This accurately describes Fossil Filter™. EPA further mandates the use of BAT (Best Available Technology) while being "economically feasible." Fossil Filter™ meets that criteria.

As a device which removes oil and grease from water flows entering the drain, the use of Fossil Filter™ is very appropriate for inclusion in SWPPPs as a means of mitigating stormwater runoff pollution.
6) HOW IS FOSSIL FILTER™ INSTALLED:
IN A FOUR-SIDED-DROP INLET?

There are two options for the four-sided inlet. The first is four paned-in corner sections are cut to appropriate length to fit the inside dimensions of the inlet and connected together. The separations are then installed either by hanging the unit on the grate bearing surface or with the use of lag bolts. The filter cartridges (4) are cut to length, fitted to about 3/4 full with Fossil Rock™ (the approved adsorbent material), and installed in the Fossil Filter™ frames.

The second option is a pre-formed one-piece fiberglass Fossil Filter™ with Silt Basin. The unit's trim-to-fit flange is cut to fit inside the inlet and rest on the grate bearing ledge. The unit's filter cartridge process is as above.

IN A CURB INLET or TRENCH DRAIN?

Straight rail sections are cut to the length of the curb or trench drain opening and end caps are installed on both rails. The apparatus is then installed just below the surface level across the opening using concrete anchor bolts. The filter cartridge process is as above.

IN A ROUND INLET?

The round units are installed by merely removing the inlet grate and lowering the unit to where the adjustable flanges rest on the grate bearing ledge. The lower screen is put in place, the Fossil Rock™ Adsorbent is poured on top of the bottom screen, and the top screen installed.

7) WHEN INSTALLED, WILL THE FOSSIL FILTER™ INHIBIT THE FLOW OF WATER?

No. Fossil Filter™ is designed to remove harmful pollutants during initial and low flows (“first flush”), when the bulk of the surface-accumulated contaminants enter the inlet. Furthermore, the hydrodynamic characteristics of the installed Fossil Rock™ adsorbent allows the water to flow smoothly through the filter. In the event of very heavy flows which exceed flow-through capability, the filter’s design allows the excess water to flow over the inside edge of the filter rail, into the overflow bypass area, and then on into the drainage system.

8) HAS THE FOSSIL FILTER™ BEEN SUBJECT TO HYDROLOGICAL TESTING?

Yes. Last May 1993 tests by Sandine Engineering Associates of Santa Rosa, California showed that installed Fossil Filter™ units exceed maximum design flow of the inlet and they would effectively filter in excess of 10 gallons per minute per linear foot of filter.

9) WHAT IS THE ADSORBENT? IS IT HAZARDOUS?

According to the manufacturer’s supplier, Fossil Rock™, the PH-extracting adsorbent material, is a natural material known as Aluminum Silicate, a blend of minerals that contain non-hazardous ingredients, as defined by the Federal EPA, OSHA (Occupational Health and Safety Administration) and WHO (World Health Organization). However, if the material is used in a certified area, or if the person replacing the filter material is allergic to dust, we recommend using a paper mask to avoid inhaling from inhalation of fine particles. Fossil Rock™ contains no reactive chemicals, is non-carcinogenic, non-biodegradable and non-leaching, non-toxic, non-flammable and non-injurious to animals, cement, carpet, tile, soil, or plant life. (See the product’s Material Safety Data Sheet.) Fossil Filter™ with Silt Basin incorporates a “Heavy Metal Skirt” which is a polyester substrate that is treated with Zolite, a product used to remove heavy materials from water through an “ion exchange” process. Once collected, the metals, etc., will not leach unless exposed to sodium chloride salt, as used in snow removal. The product is not hazardous in any way because Zolites are natural products and the polyester is a synthetic non-woven fabric with no toxicity.
10) HAVE THE ADSORBENT MATERIALS BEEN TESTED FOR EFFICIENCY? According to Zoolite's supplier, Fossil Rock™ will adsorb approximately 1.92 gallons of liquid contaminant per cubic foot of adsorbent. Therefore, a typical 24"x24" filter, which contains approximately 56 cubic feet of Fossil Rock™, would adsorb approximately 1.98 gallons of liquid contaminant. Regarding the Zeolite/polyester Heavy Metal Skirt, this is a new application and has not been tested for efficiency, however Zeolites have long been proven to be effective in the removal of heavy metals.

11) WHAT ARE THE MAINTENANCE REQUIREMENTS? WHAT IS THE USEFUL LIFE OF THE INSTALLED ADSORBENTS? As with all products subject to the abuses of nature and individuals, the installed Fossil Filter™ requires inspection on a regular basis and all foreign objects (leaves, cans, cigarette butts, etc.) be removed. The area around the installations should be swept on a regular basis. The installed Fossil Rock™ adsorbent should be inspected and replaced if the surface of the granules are more than 50% coated with contaminant and/or the unit has become clogged with silt (see #12). It is recommended that the units be inspected at least three times per year. Inspections should occur once before the beginning and twice during the rainy season.

The useful life of the installed Fossil Rock™ and heavy metal skirt (Silt Basin mode only), under normal usage, is estimated to be about six months. Areas with heavy vehicle traffic may require more frequent changes.

12) WILL THE FOSSIL FILTER™ FUNCTION EFFECTIVELY IN AREAS OF HEAVY DEBRIS OR SILT? Yes, however, in such areas, use of a dual stage filter is recommended. The first (upper) stage filter catches the silt and debris during its filtering life. If it becomes clogged, the water will flow into the second (lower) stage and be filtered. If the product is maintained according to EPA's Best Management Practices (BMP) and the manufacturer's recommendations (#1 above), the Fossil Filter™ will function effectively.

13) ARE THERE KNOWN "ACCEPTED" PRODUCTS CURRENTLY ON THE MARKET THAT FUNCTION AS EFFICIENTLY AS FOSSIL FILTER™ IN THE REMOVAL OF CONTAMINANTS FROM WATER RUNOFF? Until the creation of Fossil Filter™, the Best Available Technology (BAT) was underground large capacity concrete outfall separators. Compared to Fossil Filter™ they are less efficient and more expensive to install and maintain. In addition, they are not suitable for post-construction (retrofit) installation.

14) WHAT IS THE COST PER INSTALLATION OF FOSSIL ROCK™ ADSORBENT OR THE HEAVY METAL SKIRT? One ten pound bag of Fossil Rock™ contains 1.3 cubic feet of adsorbent and costs $23 while one 24"x24" Fossil Filter™ contains about 56 cubic feet of adsorbent. So, it would cost approximately $12 to replace the adsorbent in one unit. It would cost $15.00 for one heavy metal skirt.
15) **ONCE REMOVED FROM THE FOSSIL FILTER**, IS THE ADSORBENT CONSIDERED HAZARDOUS MATERIAL? HOW IS IT DISPOSED OF?

Even though Fossil Rock is a non-leaching and environmentally friendly substance, once it is exposed to contaminants, it technically becomes "Used Oil Adsorbent Material" with disposal regulations similar to those for oily rags. Classification and disposal regulations may vary from state to state and even from landfill to landfill. Therefore, prior to disposal, maintenance personnel should consult their local regulatory agency to ensure compliance with local and state environmental regulations.

16) **ARE FOSSIL FILTER INSTALLERS AVAILABLE? ARE MAINTENANCE PLANS AVAILABLE?**

Yes, on both counts. Fossil Rock is sold through KriStar certified distributors who can provide "Full Circle Service". They can sell, install, maintain the units and dispose of the used adsorbent.

17) **WHAT DOES A TYPICAL MAINTENANCE PLAN INCLUDE? COST?**

For a normal installation (low site, debris and contaminants count problems), most distributor maintenance plans include three inspections with the debris being removed, a general cleanup around the area and a one time replacement of the adsorbent. It will normally cost less than $150.00 for the three visit plan per Fossil Filter unit, depending on the number of units, distance to travel and so forth.

18) **HOW DO I GET MORE INFORMATION ON FOSSIL FILTER AND ITS PROGRAMS?**

Contact KriStar's national office in Santa Rosa, California toll free 1-(800)-579-8819.
FOSSIL FILTER™
GENERAL SPECIFICATIONS
FOR SILT BASINS™

Scope:

This specification describes a catch basin filtration system that incorporates EPA-approved adsorbents installed in a drainage inlet to collect petroleum-based contaminants while permitting the undisturbed passage of water.

Material Properties:

The trough shall be manufactured from petroleum resistant fiberglass and include an area to retain silt and debris so as not to stop up the drainage system. The filter screens shall be of stainless steel Type 304. The filter media shall be an adsorbent material that contains no hazardous ingredients as defined by the U.S. Environmental Protection Agency (EPA), U.S. Occupational Safety and Health Administration (OSHA), and the World Health Organization (WHO).

Installation:

Installation shall be performed by certified Fossil Filter™ installer. A Fossil Filter™ Installation Record, to be provided upon installation, shall be kept by the end user.

Maintenance and Disposal:

Maintenance services shall be provided by certified Fossil Filter™ maintenance provider. A Fossil Filter™ Maintenance Record, to be provided upon installation, shall be kept on site by the end user.

Disposal of exposed filter media shall be in accordance with local regulatory agency specifications to ensure compliance with all local and state environmental legislation.
# Fossil Filter™

## SPECIFIER CHART
(Northern California)

### CATCH BASIN

<table>
<thead>
<tr>
<th>STANDARD (SINGLE STAGE)</th>
<th>CHRISTY</th>
<th>HANSON</th>
<th>HYDRO CONDUIT</th>
<th>S. R. CAST</th>
<th>TECHCERY</th>
<th>WESTERN</th>
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<tbody>
<tr>
<td>FF - 2424</td>
<td>U2424</td>
<td>P24</td>
<td>D22</td>
<td>3K</td>
<td>V2424</td>
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<td></td>
<td>3K</td>
<td></td>
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</tr>
<tr>
<td>FF - 3030 (see note 1)</td>
<td></td>
<td>P30</td>
<td></td>
<td>3K</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>FF - 3636 (see note 1)</td>
<td>U2366</td>
<td>D36</td>
<td>D33</td>
<td>3M</td>
<td>V3636</td>
<td>85</td>
</tr>
</tbody>
</table>

### SILT BASIN

| SB - 24 (see note 1)    | U2424   | P24    | D22           | 2K        | V2424    | 45      |
| SB - 2436 (see note 1)  | U2436   | P2436  | D23           | 3L        | V2436    | 65      |
| SB - 30                 |         | P30    |               | 3K        |          | 75      |

### ROUND FILTERS

| RF - 24                 | CB24    | CB24   | SB24          | A1024     | A1024    |
| RF - 30                 | SBF1975 |        | SBF1975       | A1075     | A1075    |

### CURB INLETS (DUAL STAGE)

| FF - 28CI               | P284C   |        | 2 1/2A        | 2430      |
| FF - 28CI               | P36C    |        | 3AC           | 3146      |
| FF - 48CI               | P484C   | D24C34C| 4A4AC         | 5468      |

### NOTES:

1. ABOVE REFERENCED FILTERS ARE MANUFACTURED TO FIT PRECAST CONCRETE DRAINAGE INLETS NOTED.
2. ADDITIONAL STANDARD AND CUSTOM SIZES ARE AVAILABLE.
3. DUAL STAGE FILTERS MAY BE SPECIFIED.
4. FOR LARGER INLETS NOT LISTED, SILT BASIN FILTERS MAY BE INSTALLED SIDE BY SIDE.

For additional information contact:
KrisStar Enterprises, Inc., at (800) 579-8819 or fax us, (707) 525-4973
FOSSIL FILTER FLANGE RESTS ON GRATE BEARING LEDGE
LIMITED WARRANTY
KRISTAR ENTERPRISES, INC.

TO THE EXTENT PERMITTED BY THE LAW OF YOUR JURISDICTION, THIS LIMITED WARRANTY LIMITS OR EXCLUDES CERTAIN WARRANTIES OR RIGHTS OTHERWISE PROVIDED BY LAW.

Kristar Enterprises, Inc. ("Kristar") hereby warrants its products to be free from defects in material and workmanship for a period of one (1) year from the date of original purchase by the person or entity purchasing Kristar's products directly from Kristar or from Kristar's authorized representatives or resellers ("Purchaser"). There are no other warranties or representations with respect to the nature or quality of Kristar's products. Under no circumstances shall Kristar be liable for incidental, consequential, or other or additional damages of any kind or nature whatsoever, including without limitation, shipping, and freight charges, installation and/or removal expenses including labor, interest, attorney fees, or other costs, whether such claim is based upon principles or theories of contract, warranty, negligence and/or tort law.

IT IS EXPRESSLY AGREED THAT THIS WARRANTY IS THE EXCLUSIVE AND ONLY WARRANTY TO PASS WITH KRISTAR'S PRODUCTS, AND THAT THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, INCLUDING WITHOUT LIMITATION, THOSE OF FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY.

In the event such disclaimer of implied warranties is held to be unenforceable or otherwise invalid, or if Purchaser or any third party, including without limitation employees, agents, contractors, subcontractors, and/or representatives of Purchaser, claim Kristar is liable for negligence arising from the manufacture of its products, or if for any other reason a claim is made that Kristar has not fully satisfied its obligations with respect to its products, Kristar's liability is limited to an amount equal to two (2) times the original purchase price of Kristar's products proven to be defective, exclusive of any applicable taxes. Purchaser hereby agrees to indemnify, defend and hold Kristar harmless in the event any third party brings a claim against Kristar relating to its products.

Any claim for breach of this warranty must be submitted within one year from the date of original purchase and must be in writing, addressed to President, Kristar Enterprises, Inc., 422 Larkfield Center, Suite 271, Santa Rosa, CA 95403. Only a corporate officer (President, Vice President, or Corporate Secretary) of Kristar shall have the authority to modify this warranty, and any such modification must be in writing and signed by the corporate officer, including reference to said officer's title, to be effective.

If a dispute arises out of or relates to this Limited Warranty, or performance or breach thereof, Kristar and Purchaser agree first to try in good faith to resolve the dispute by mediation under the Commercial Mediation Rules published by the American Arbitration Association before resorting to arbitration. Thereafter, any remaining unresolved controversy or claim arising out of or relating to this Limited Warranty, or performance or breach thereof, shall be resolved by binding arbitration in accordance with the Commercial Arbitration Rules published by the American Arbitration Association, and shall be conducted in Santa Rosa, California. The sole Arbitrator shall be a retired or former judge familiar with commercial and construction matters. Judgment upon the award rendered by the Arbitrator may be entered in the Sonoma County court having jurisdiction thereof.

Purchaser's initials: _______________
KriStar Enterprises, Inc., the manufacturer of

**Fossil Filter**

is proud to announce:

**The New One Piece**

"Drop In" **Fossil Filter**

designed to fit various industry standard precast catch basins

★ The new "Drop In" design requires **NO** special installation equipment

★ New easy installation allows YOUR OWN CREW to install

★ For the ease of ordering, simply note the manufacturer and model number of catch basins to be fitted.

★ Please refer to the Fossil Filter specifier chart

★ May now be purchased directly from the Manufacturer

---

For odd sized or shaped inlets
The original **Fossil Filter**
will continue to be available

For the installation of *The original Fossil Filter*,
KriStar Enterprises can recommend a certified installation company in your area.

Call KriStar Enterprises, Inc., (800) 579-8819, for prices and availability
NOTES:
1. Catch Basin/Filter body shall be one-piece construction molded from fiberglass which meets or exceeds PS15-69.
2. Grate and frame shall be fabricated from steel or aluminum in accordance with ASTM A123.
3. Grate shall have maximum spacing of 1/2" between bearing lines in accordance with ADA requirements and shall be secured with locking bolts.
4. Grate shall be designed for 1500 #. 
5. Filter screen and screen frame shall be stainless steel (type 304). All screens shall be 8 mesh.
6. Catch Basin may be specified with single or multiple outlet pipes (2, 4, or 6 dia.).
7. Filter medium shall be Fossil Rock™, insolated and maintained in accordance with manufacturer recommendations.
8. A minimum cover of 6” is required over outlet pipe(s).
9. Catch Basin may be specified without sump sump.
TYPICAL
TRENCH DRAIN INLET

This installation requires a Fossil filter without the flange to allow the filter to be lowered to catch the trench drain. Attach to drive wall with concrete anchors.

STANDARD
FLARED END SECTION

This installation to be used as a method of catching any remaining pollutants prior to flowing into stream.

ADJUSTABLE
FLANGE EXTENSION

The adjustable flange extension, when attached to the Fossil Filter without flange, increases the resting depth of the Fossil Filter within the drainage inlet.
INSTALLATION GUIDELINES

For Standard and Curb Inlets

STANDARD GRATE INLET

STEP 1: Remove inlet grating.

STEP 2: Set Fossil Filters™ into drain inlet, resting flange on grate bearing surface.*

* For drain inlet sides without grate bearing surface, pre-fabricated units with or without flange are available. Follow Step 3 of Curb Opening Inlet for installation instructions.

CURB OPENING INLET

STEP 1: Measure width of curb opening inlet and cut rail section to appropriate length.

STEP 2: Install two rail sections end caps (right and left sides) by drilling two 1/8" holes through pre-drilled holes in each end cap and securing with pop-rivets.

STEP 3: Drill three or more holes (depending on inlet size) in the inside wall of the curb opening inlet to accommodate expansion anchors (3/8" x 2" SS bolts). Drill matching holes in Fossil Filters™ rail section and secure the assembled Fossil Filters™ trough apparatus to the inside wall with bolts (see attached Wall Mounting Detail).

FOSSIL FILTER™ FILTER CARTRIDGE ASSEMBLY

STEP 1: Measure inside dimension of installed Fossil Filters™ trough area and cut filter cartridge to length, allowing 1/4" on each side for end caps.

STEP 2: Cut both top and bottom filter cartridge screens to match length of filter cartridge. Set bottom screen into filter cartridge and secure to bottom using stainless steel wire ties.

STEP 3: Slide top screen into top flange of filter cartridge and install one end cap by drilling two 1/8" holes through pre-drilled holes in the end cap and securing with pop-rivets.

STEP 4: Set the filter cartridge on end and fill the cartridge with Fossil Rock™ absorbent material through the open end. The absorbent material should rest within 1 1/2" of the top screen when the filter cartridge is horizontal. Do not overfill.
MAINTENANCE GUIDELINES

BACKGROUND

When installed in a drainage system (per KriStar instructions and specifications), Fossil Filter™ is an effective tool in the efforts to reduce pollution of lakes, rivers, streams and oceans caused by contaminants borne in stormwater runoff.

Within the United States, the federal Environmental Protection Agency (EPA) has mandated that states and cities take action to curtail pollution from stormwater runoff. The EPA cites Best Available Technology (BAT) criteria for states and cities to use. Fossil Filter™ meets that BAT criteria.

NEED FOR AN EFFECTIVE MAINTENANCE PROGRAM

Once installed, the Fossil Filter™ becomes subject to the provisions of the EPA's Best Management Practices (BMP) dictates. According to the EPA, BMP includes the development of a plan to prevent pollution from stormwater runoff. A natural component of that plan is the establishment of an overall maintenance program. In the absence of an established maintenance program, KriStar Enterprises cannot guarantee the effectiveness of the Fossil Filter™.

An effective maintenance program, where Fossil Filter™ is installed, includes the following key components:

1. INSTALLATION RECORD
   At the time of installation, both the installer and owner must complete and sign the Fossil Filter™ Installation Record (see Example A). The white copy is to remain on file with the owner, the yellow copy must be faxed or mailed to KriStar Enterprises, and the pink copy is to be retained by the installer.

2. MAINTENANCE RECORD
   At the time of the installation, the installer and owner must complete the top portion of the Fossil Filter™ Maintenance Record (see Example B). This record is to remain on file with the owner in the owner's manual so that he may accurately document the maintenance provided.

   To ensure compliance with EPA mandates, it is the responsibility of the owner to establish, sustain, and record the performance of a regular maintenance program. Again, in the absence of an established maintenance program, KriStar Enterprises cannot guarantee the effectiveness of the Fossil Filter™.
3. **REGULAR SWEEPING**

   The surface subject to runoff should be swept regularly during dry periods to remove contaminated dirt, silt, and loose debris.

4. **REGULAR INSPECTIONS**

   The Fossil Filter™ filter cartridge should be visually inspected on a regular basis as follows:
   a) For areas with a definite rainy season, filter cartridges should be inspected prior to and just after the rainy season.
   b) For areas subject to year-round rainfall, filter cartridges should be inspected on a recurring basis, but no less than every six months.
   c) For areas with winter snow and summer rain, filter cartridges should be inspected prior to and just after the snow season.

5. **CONDUCT OF THE VISUAL INSPECTION**

   a) The inlet grate is removed and set aside.
   b) The installed filter cartridge(s) must be lifted from the trough, one of the end caps removed, and the adsorbent inspected.

   As you lift the filter cartridge from the trough and remove an end-cap, look for any silt and/or debris resting just under the top screen on top of the adsorbent material. If the adsorbent granules are more than one-half covered with a black substance, the filter cartridge should be replaced with clean adsorbent material (for replacement, see step 8 below). The end cap is then replaced, the filter cartridge set back into the trough, and the inlet grate replaced.

6. **REPLACEMENT OF THE INSTALLED ADSORBENT MATERIAL**

   a) Notes: The person replacing the adsorbent material should move away from the inlet so as to avoid spilling the contaminated material into the drainage system.

   The filter cartridge end cap is removed and the contaminated material dumped from the cartridge into a disposal bag or bin. A sufficient amount of clean adsorbent material is then poured into the filter cartridge to a level within 1 1/2” of the top screen when the cartridge is horizontal. Do not overfill.

7. **DISPOSAL OF THE USED ADSORBENT**

   Fossil Rock™ is designed to absorb petroleum-based pollutants. Because it has been proven to be a non-leaching product, the used adsorbent material may be taken to a local landfill. However, disposal regulations vary by area. Therefore, we recommend that Fossil Filter™ maintenance companies contact their local regulatory agency prior to disposal to ensure compliance with local and state environmental legislation.

8. **REPLENISHMENT OF ADSORBENT MATERIAL SUPPLY**

   A sufficient amount of Fossil Rock™ adsorbent material should be kept on hand to replace the amount of adsorbent material plus an additional amount to be used in case of oil spills. To order Fossil Rock™ adsorbent material, contact KrisStar Enterprises at (800) 579-8819.

   At this time, Fossil Rock™ adsorbent material is the only tested and approved adsorbent material for use in the Fossil Filter™ product. KrisStar Enterprises cannot verify a similar level of effectiveness with the use of other adsorbents.

   If you have any questions about the Fossil Filter™ product or the Fossil Rock™ adsorbent material, please call KrisStar Enterprises at (800) 579-8819, or the Fossil Filter™ Representative in your area.
FOSSIL FILTER™
GENERAL SPECIFICATIONS
FOR STANDARD UNITS

Scope:

This specification describes a catch basin filtration system that incorporates EPA-approved adsorbents installed in a drainage inlet to collect petroleum-based contaminants while permitting the undisturbed passage of water.

Material Properties:

The trough and filter cartridge shall be manufactured from 16 gauge, galvanized sheet metal. The filter media shall be an adsorbent material that contains no hazardous ingredients as defined by the U.S. Environmental Protection Agency (EPA), U.S. Occupational Safety and Health Administration (OSHA), and the World Health Organization (WHO).

Installation:

Installation shall be performed by certified Fossil Filter™ installer. A Fossil Filter™ Installation Record, to be provided upon installation, shall be kept by the end user.

Maintenance and Disposal:

Maintenance services shall be provided by certified Fossil Filter™ maintenance provider. A Fossil Filter™ Maintenance Record, to be provided upon installation, shall be kept on site by the end user.

Disposal of filter media shall be in accordance with local regulatory agency specifications to ensure compliance with all local and state environmental legislation.
NOTES:
1. Filter body shall be of fiberglass manufactured to meet or exceed PS 15-69.
2. Top Flange shall be galvanized steel (18 gauge) cut or trimmed as required to fit below the grade of drainage inlet.
3. Top and bottom screens and screen retainer clips shall be stainless steel (Type 304).
4. Heavy metal filter skirt material shall be treated to retain heavy metals.
5. For manufacturer warranty purposes:
   a. Filter medium shall be Fossil Rock.
   b. Fossil Filter™ shall be installed by a manufacturer-certified installer.
   c. Refer to manufacturer's recommendations for maintenance program.

DIMENSION CHART

<table>
<thead>
<tr>
<th>MODEL NO</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
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<td>4</td>
<td>11</td>
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</table>

MODEL SB-24: For 24"x24" I.D. Drop Inlet
MODEL SB-25: For 30"x30" I.D. Drop Inlet
MODEL SB-2436: For 24"x36" I.D. Drop Inlet

NOTE: Top Flanges that enable this product to be installed in larger and/or nonstandard discharge inlets are available.

FOSSIL FILTER™ WITH SILT BASIN

KilkStar Enterprises, Inc., Santa Rosa, CA (800) 578-6819
NOTES:
1. Filter body shall be of fibreglass manufactured to meet or exceed PS 15-69.
2. Top Flange shall be galvanized steel (18 gauge) cut or trimmed as required to fit below the grate of drainage inlet.
3. Top and bottom screens and screen retainer clips shall be stainless steel (Type 304).
4. For manufacturer warranty purposes:
   a. Filter medium shall be Fossil Rock.
   b. Fossil Filter™ shall be installed by manufacturer-certified installer.
   c. Refer to manufacturer's recommendations for maintenance program.

DIMENSION CHART

<table>
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<tr>
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</table>

NOTE: Top Flanges that enable this product to be installed in larger and/or nonstandard drainage inlets are available.

FOSSIL FILTER® ROUND
Klister Enterprises, Inc., Santa Rosa, CA (800) 579-8619
List of Manufacturers Contacts for Storm Water Treatment Devices Per Joanne McLaughlin
I am looking for objective, third-party data that compares the sediment and oil removal rates from stormwater runoff for conventional catch basins vs. the new technologies that are available (e.g., Vortex).  

A local environmental planner tells me that there are some local municipal engineers who are not convinced by manufacturers' data that the new systems are more effective than conventional systems (e.g., catch basins with sumps, or two-chamber catch basins where sediments drop out in the first and there is an oil sock to collect oils in the second chamber). 

Does this kind of data exist and where?  Also, what other convincing information is available other than that re-entrainment and resuspension of sediments will occur in conventional systems with each successive storm? 

The following is a summary of responses.  Thanks to all for your help. 

Joanne McLaughlin  
NH Coastal Program
Defender. You can get a hold of these reviews through the Massachusetts Executive Office of Environmental Affairs (Paul Richard 617-727-9800 Ext= 446).

Eric Winkler, Ph.D.
Strategic Envirotechnology Partnership
University of Massachusetts at Amherst
413-545-2623

From: Andrew J. Reese <ajreece@oes.com>
The city of Seattle did a study on catch basin inlets - contact them for
info.
Andy Reese=22
Opcon Environmental

>From Ed Molash <MOLASHE@wsdot.wa.gov>

This is premature, but WSDOT will monitor stormceptor and vortechs over the
next 2 years to evaluate removal efficiencies for a variety of
constituents, including TPH. We also have doubts about product vendor's
data. We'll release our data after we analyze a statistically significant
number of samples. General info on WSDOT's experimental BMP and stormwater
monitoring plan can be found within our NPDES stormwater management plan,
which can be located and downloaded at:
http://www.wsdot.wa.gov/restore/rv/environmental/WSSManuals.htm

Ed Molash
WSDOT - Water Quality Engineer
360-705-7507

From: Gordon England <gengland@mindspring.com>

We have been experimenting with various devices, booms, etc. for several
years and have several conclusions. Booms or pads of oil absorbent
material do grab hydrocarbons. If they stay wet in inlets a heavy bacteria
grows on them reducing their effectiveness...In dry inlets they tend to get
covered with dirt which also hurts them. We tried to send them to labs for
analysis but they are also made of hydrocarbons and the labs could not tell
us much. >20

More importantly, we concluded that for most lands the use of the oil loadings
were very minimal and it was not cost effective to remove small amounts of
hydrocarbons. When hydrocarbons reach the rivers they evaporate and
oxidize fairly rapidly so these pollutants are very low on our priority list. Of course in industrial or commercial uses with automotive repairs
or parking lots you will find concentrated loadings needing BMP's.

Oil water separators will work but they cannot take large flows do to their
separator plates. And they are expensive. The best product we have found are fiberglass inlet inserts that trap oils effectively. They are only a
few hundred $ and drop into existing inlets. These are made by Suntree
lakes in Cape Coral, Florida-407-635-0444. >20

Good luck
Gordon England
Brevard County

Printed for "Eugene P. Dashiel" <dashiel@jaya.net>
Stormwater Utility

From: Mark and Diane <mdlbmbdb@carlsbadnm.com>
After completing a study of structural best management practices for a site which precluded the use of any land intensive solution, I found that only five out of nine of the BMP's evaluated had third party evaluation of pollutant removal efficiencies. Some are exhaustive and others are marginal. They are Bioretention, CSF=AB, Fossil Filter TM, StormCaptor=AB =
and StormTreat TM. The contacts for the technologies evaluated in the report are listed below:

BaySaver TM =09
BaySaver, Inc.
1010 Deer Hollow Drive, Suite 111
Mt. Airy, MD 21771
Mark Heusner
(301) 820-6119

Bioretention =09
Biohabitats incorporated
15 West Aylesbury Road
Timonium, MD 21093
J. Keith Bowers
(301) 337-3659

CSF=AB =09
Storm water Management
2035 N.E. Columbia Blvd.
Portland, OR 97211
Felton Wilson, P.E.
1-800-548-4867

Downstream Defender TM =09
H.T. Technologies
94 Hutchins Drive
Portland, ME 04102
John Bolata
1-800-649-2706

EnviroDrain=AB Filters=09
Enviro-Drain
13226 97th Avenue, NE, C208
Kirkland, WA 98034.
Jim Hutter
206-620-1953

Fossil Filter TM =09
KriStar Enterprises, Inc.
422 Larkfield Center, Suite 271
Santa Rosa, CA 95403
Doug Ailard
1-800-579-8819

StormCaptor=AB =09
StormCaptor Corporation
800 Jefferson Plaza
Suite 304
Rockville, MD 20852
Vincent Berg, F.E.
1-600-762-4703

StormTreat Systems TM =09
StormTreat Systems, Inc.
90 Route 6A, Sextant hill Unit 1
Sandwich, MA, 02563
Mark Nelson
(508) 833-1033

Vortechs TM =09
Vortechs, Inc.
41 Evergreen Dr.
Francis Tighe

Printed for "Eugene P. Dashiel!" <dashiel@java.net>
Portland, ME 04103
(207) 878-3662

Regarding your search on conventional systems, caution should be exercised on the ability of these systems to contain pollutants during significant storm events. Many of the new technologies incorporate strategies to avoid re-suspension. The contacts above may offer a starting point for research on conventional systems, but it is best to sample other sources as well. Try EPA's web site. I have found it useful on a variety of subjects.

Good luck on your search,

Mark Bremer, P.E.
Civil Engineer
National Park Service
Carlsbad, NM

Peace,
Mark
U Aquashield
Stormwater Filters
for Street Storm Drain Catch Basins
Manufacturers Literature
February 13, 1998

Eugene P. Dashell
Environmental Plans and Assessments
1314 South King Street
Suite 951
Honolulu, Hawaii 56814

Dear Mr. Dashell:

Thank you for your inquiry about the AquaShield™ Filtration System. Enclosed is a Qualification Statement for the technology which provides detailed information about the three models that Remedial Solutions, Inc. (RemSol) offers to meet site specific needs.

The AquaShield™ technology complies with the seven guiding principles for an Environmentally Preferable Product according to Executive Order 12873, Section 503 and Section 6002 of the Resource Conservation and Recovery Act for buying recycled products. The AquaShield™ is made from recycled materials and uses a filter media composed of 100% recovered materials that would otherwise be placed in a landfill.

RemSol is pleased to offer the AquaShield™ technology as an affordable means of pollution prevention for stormwater and wastewater discharges. The performance is backed by our limited warranty that is included in our service agreement. It is accepted as a Best Management Practice (BMP) by the city of Chattanooga which is recognized by the Center of Excellence, Environmental Best Manufacturing Practices Program as a leader in environmental compliance for nonpoint source pollution prevention and stormwater management.

I will contact you soon to answer any additional questions you may have about the AquaShield™. In the meantime, I have included order forms for your information and use. The surface drain model form includes subsurface measurements that are important considerations for properly sizing your unit. The convergence flow model form also identifies critical information RemSol needs to meet your site specific needs. The mobile unit is sized and priced according to the anticipated maximum flow requirements on a case by case basis.

Again, thank you for your interest in the AquaShield™ Filtration system. I look forward to speaking with you soon.

Sincerely,

[Signature]

J. Kelly Williamson
President
Qualification Statement

The AquaShield™ Filtration System technology is a highly effective means of pollution prevention for Nonpoint Source Pollution (NSP). The systems protect the waters of the Community and State by removing pollutants from stormwater runoff and wastewater discharges. Contaminated water enters the system and the contaminants of concern are extracted via a unique multi-stage filter process using a patented media made of 100% recovered materials. The AquaShield™ Filtration Systems have proven to be up to 100% effective in the removal of contaminants through independent testing by a certified laboratory.

Remedial Solutions, Inc. (RemSol) developed, manufactures, sells and services the AquaShield™ Filtration Systems. The purpose of the systems is to provide the users an economical and effective means of pollution prevention for compliance with NSP, stormwater and wastewater discharge requirements. AquaShield™ Filtration System technology is approved as a "Best Management Practice" (BMP) when the systems are properly maintained.

This Statement provides information demonstrating that the AquaShield™ complies with the seven guiding principles for an Environmentally Preferable Product according to Executive Order 12873, Section 503 and section 6002 of the Resource Conservation and Recovery Act.

A patent is pending on the AquaShield™ technology which offers three models to meet variable site-specific conditions. The first model, as shown on our company brochure, is adaptable to most any size or shape of existing or new surface drainage opening and is simple to install. This model is excellent for compliance with stormwater and wastewater discharge requirements and is easy to service. The second model is designed for heavy flow conditions at the convergence of several surface inlets. This model is also simple to maintain and requires some light construction for installation. The third model is a mobile treatment unit that can filter large volumes of water from excavation sites, secondary containment dikes, emergency response conditions and remote areas.
General Operation Description

The process by which the AquaShield™ Filtration Systems operate is simple. There are no moving parts in any of the three models. The units are typically constructed of stainless steel to withstand harsh conditions and provide long term service. A routine maintenance program is established for each unit based on the volume or load of the contaminants of concern, the frequency of releases of contaminants at the facility or location, and the nature of the surface being drained or the area where the water is being removed.

Each of the three models operate basically in the same manner. A simplified process flow diagram is included with this document as Figure 1. The flow of the incoming wastewater begins the process of the filtration. The wastewater flows by gravity (or can be pumped into the mobile unit) into the primary sediment removal stage to capture and extract unwanted debris and suspended solids. The wastewater then moves through a series of filters composed of a patented media made of 100% reclaimed materials. The filter media is hydrophobic and captures the contaminants of concern while allowing the water to continue to pass through the filtration process. The filter media is licensed as an oil spill cleanup agent (OSCA) by the California State Water Resources Control Board. Typically, there are at least two of these filter stages in the surface drainage opening model (SD-100) while the heavy duty convergence flow model (CF-200) has several filter stages. A polishing filter stage is normally used prior to discharge of the treated water. Sampling ports are included to ensure regulatory compliance and that the efficiency of the system is maintained.

Typically, the highest concentrations of contaminants are present in the initial flow of stormwater runoff and wastewater discharges. For example, during a qualified stormwater sampling event, samples of the discharge water are obtained during the first hour of the rainfall event. Special emphasis is given to the “first flush” of runoff water in the sampling procedures because of the increased amount of pollutants at that time. As the rainfall event continues, the concentrations of contaminants
often decrease for nonpoint sources.

The filter media does not allow the captured contaminants to be released once absorbed into the material. This is a unique quality of the AquaShield™ Filtration Systems which allows superior performance in extreme conditions. The technology involves the treatment by filtration and recycling of water and aqueous wastes including but not limited to the following:

- wastewater, stormwater, free-phased organics, petroleum spills,
- nonpoint source discharge water, vehicle washdown waste water,
- wastewater from secondary containment dikes, excavation and construction sites, underground storage tank removals, emergency response conditions, remote wash down areas, and captured water at stream crossings for timber cutting sites.

Descriptions of the AquaShield™ for surface drainage openings and for heavy-duty convergence flow conditions are provided below. These systems are compatible as fixed treatment technology of the wastestreams identified above. A description of the mobile treatment model is included in a separate document.

AquaShield™ Filtration System: SD-100

The AquaShield™ for surface drain catch basins (SD-100) is made of stainless steel because of its superior ability to withstand harsh conditions that are encountered where various chemicals could degrade other possible construction materials. Our system is compatible with most any size or shape catch basin to allow ease of use in variable site conditions. The SD-100 can be installed in surface openings of stormwater dry wells or leaching pools designed as detention basins. An adaptor directs the water entering the catch basin into the filtration system without restricting the normal surface flow. The filter stages can be added or removed from the system depending on the specific needs of the site and the size of the basin. A sampling tray is included with most systems for compliance purposes. A standard stormwater or surface water sampling device can be used to obtain representative samples after
filtration has occurred.

The cost for a typical SD-100 system and a one year supply of filter media is shown below. This example is designed for maximum flow through a normal 2 ft. x 2 ft. storm drain and can remove up to 16 gallons of petroleum hydrocarbons before changing filters.

<table>
<thead>
<tr>
<th>CONSTRUCTION</th>
<th>FILTRATION</th>
<th>PRICE</th>
<th>QUANTITY</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless steel (#304)</td>
<td>3-stage</td>
<td>$1,550.00</td>
<td>1</td>
<td>$1,550.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MAINTENANCE</th>
<th>FREQUENCY</th>
<th>PRICE</th>
<th>QUANTITY</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 filter</td>
<td>Bi-Monthly</td>
<td>$45.00/ea</td>
<td>6</td>
<td>$270.00</td>
</tr>
<tr>
<td>#2 filter</td>
<td>Quarterly</td>
<td>$45.00/ea</td>
<td>4</td>
<td>$180.00</td>
</tr>
<tr>
<td>#3 (polishing) filter</td>
<td>Semi-annual</td>
<td>$20.00/ea</td>
<td>2</td>
<td>$40.00</td>
</tr>
<tr>
<td>Sample Tray</td>
<td>N/A</td>
<td>N/C</td>
<td>1</td>
<td>N/C</td>
</tr>
</tbody>
</table>

The filter replacement schedule is highly dependent on factors such as the volume of the contaminants of concern, the frequency of spills at a facility, and the physical nature of the surface being drained. This typical system assumes that the potential for contamination is low to moderate as might be encountered in a frequently used parking lot.

To compare to past practices, the AquaShield™ system priced above costs 81% less than a system that requires higher installation costs and maintenance. For example, a typical 1,000 gallon oil water separator equipped with an electronic alarm system will cost more than $8,224.00 plus the installation, plumbing and electrical costs. Also, this size oil water separator will generally accommodate a 100 gpm flow rate and requires routine removal of the accumulated oil and sediments by a waste oil company at an additional charge. Furthermore, an oil water separator can release the accumulated contaminants as a result of unexpected large volumes of water flowing through the system if proper maintenance has not occurred. The AquaShield™ priced above is designed to manage approximately 280 gpm through an existing catch basin and has proven
that it does not release the extracted contaminants even in severe circumstances when the filters need replacing.

_AquaShield™ Filtration System: CF-200_

The heavy duty convergence flow model (CF-200) operates in a manner as provided in the general description above. The _AquaShield™ CF-200_ is capable of accommodating the flow from several surface drains connected to a single discharge point. The CF-200 is installed down stream of the convergence of the surface drains and connects to the existing drain piping. Installation is as simple as for a normal pre-cast concrete catch basin structure with a manway opening at the surface.

The _AquaShield™ CF-200_ provides an increased filtering capacity during normal flow for greater contaminant removal. Multiple filter stages and channels control the flow pattern of water to maximize the treatment. The CF-200 is equipped with overflow areas to allow continued water travel and not cause flooding or backup on the surface during periods of prolonged and increased drainage. The filter stages and sediment retention are easily serviced from the ground level.

The average cost for a typical 6 ft. x 6 ft. unit is $8,500.00 plus installation and maintenance. Because of the increased filtering capacity and large sediment retention, the normal maintenance is approximately $80.00 per year where the pollution load is low to moderate. This typical _AquaShield™ CF-200_ model can remove more than 60 gallons of petroleum hydrocarbons and retain approximately .40yd³ of sediment.
ANALYTICAL DATA AND OTHER INFORMATION

An independent test of the AquaShield™ system has been conducted by a certified laboratory to demonstrate the effectiveness of the system under intense field conditions. The reports from Analytical Industrial Research Laboratories, Inc. in Chattanooga, Tennessee are included with this document. Three sets of data have been produced during the course of the test. The test location is a convenience store and truck stop facility along Interstate 24 approaching Chattanooga. The AquaShield™ is in a typical catch basin near the diesel fueling island which collects stormwater runoff and the wash down water from the surrounding 13,000 ft² area. Details of the testing procedures and site specific information are included in the laboratory's performance test report.

The first set of laboratory data, sample date September 4, 1997, shows the analytical results for normal stormwater discharge parameters in milligrams per liter for the "incoming water" and the "outgoing water" from the AquaShield™. The first set of data from September 4, 1997, shows a significant reductions in the levels of TSS (75.5%), Oil & Grease (98.1%), Barium (88.6%), Chromium (95.4%), and Lead (85.2%). There is also a notable reduction in BOD (85.1%) and COD (21.1%) levels with only minor changes in pH, Air and Water temperature. The levels of Ammonia (as N) and TKN were reduced 76.6% and 81.1%, respectively.

The second sampling event on October 3, 1997 followed approximately nine inches of rainfall in September and two surface spills which totalled more than 20 gallons of diesel fuel (in addition to the normal activities at a truck stop). The filters were not replaced before the second test samples were taken. As in the first test, there are significant reductions in the levels of Oil & Grease (97.9%) and Chromium (95.4%). There is also notable reductions in BOD (57.5%), COD (62.3%), Ammonia (77.4%), TKN (60.9%), Barium (64.4%) and TSS (16.2%). Air temperature, Water temperature and pH remained constant during the testing event. It is clear that the removal of the pollutants continues even in severe circumstances when the filters need replacing.
The third set of test data on October 13, 1997 shows lower concentrations of contaminants for the incoming water and continued removal of pollution after the AquaShield™ Filtration System. The unit was serviced and new filter media installed before this sampling event. There was no rainfall recorded between October 3 and 13, 1997. As before, there are reductions in the levels of Oil & Grease (49.2%) and TSS (76.0%). There is also significant reductions in BOD (56.6%), COD (63.5%), Ammonia (75.0%), TKN (80.0%), Barium (55.0%) and Lead (44.3%). Air temperature, Water temperature and pH remained relatively constant during the testing event. There continues to be a reduction of all incoming contaminants in conditions when pollution loads are low to moderate.

Results of a toxicity characteristic leaching procedure (TCLP) analysis are also provided in the laboratory section. The results indicate non-detectable concentrations of metals and volatile organic compounds (VOCs) from a saturated (used) filter. This TCLP information will be useful in selecting the treatment/disposal alternatives.
Urban Pollution Vanquished in new Alexandria Development

Three New Technologies Debut in Four Mile Run

by Don Waye

A new generation of devices for cleaning up urban runoff is making its debut in the Four Mile Run watershed. These devices are the latest in an evolving technology known as "Best Management Practices," or BMPs, developed to clean up non-point source pollution. The Stormceptor, a sand filter, and two bio-retention stands are the three new types of BMPs being installed at the "highpoints at Stonegate" development in Alexandria. The BMP devices will clean up many of the pollutants likely to wash off the 147-townhouse development and parking lot before they have a chance to pollute Four Mile Run.

Non-point source pollution is the insidious and pervasive subset of pollution sent to our waterways that is not attributable to industrial discharge pipes or municipal sewage outfalls. It typically works like this: during dry days, pollutants associated with human activities (including pets dependent on human care) accumulate on land surfaces. During rainy days, these pollutants get washed off down nearby storm drains and into our local streams, polluting not only Four Mile Run, but also the Potomac River and the Chesapeake Bay. Walt Kelly's "Pogo" best summed up the problem of non-point source (NPS) pollution inadvertently whenever he proclaimed, "We have met the enemy and he is us!"

Stormceptors

Hailing from Canada (and now U.S. made, as well), these small devices are ideal for installing in new or existing storm drains immediately downslope of loading docks, gas stations, and other heavily industrialized sites. The Stormceptor is the patented trade name for a next-generation oil-girt separator.

- Continued on Page 2. See BMPs.

Friends of Four Mile Run has been invited to participate in an ad hoc committee to develop a vision for a "re-vitalized Alexandria," starting this October. Friends of Four Mile Run member Lee Regan, who lives in Alexandria, will be the "Friends" rep for this group. Lee works for the U.S. Geological Survey and has had a long-term interest in protecting and restoring Four Mile Run. In 1992 and 1993, Lee gave up one Saturday morning a month for a year to be a volunteer water quality stream monitor for NVPDPC Four Mile Run program. Look for a status report or two from Lee in upcoming newsletters.

INSIDE

2 Stormceptors, Sand Filters, & Bio-retention...Oh My!
3 Yucky Stuff We Found in the Stream
4 Kids Page: Who Dumped Tea in Four Mile Run?
5 Handling Household Hazardous Waste
6 Lawn Care & The Case Against Turf
7 Sparrow Swamp Update
8 News for Friends
Unlike the oil-girt separators of the 1980s which were widely used in suburban Maryland and D.C., these seem to avoid the related problems of pollutant re-suspension and frequent, expensive maintenance.

Stormceptors debuted in the U.S. last year (most notably in Maryland), and several have been approved on an experimental basis in Northern Virginia. At least two will be installed in Alexandria by year-end 1995, including the one at Highpointe. Their performance for removing pollutants will be monitored to help local governments decide whether or not Stormceptors should be widely used in Northern Virginia.

Anecdotal reports from early installations are very promising. Recently, there was a 250-gallon oil spill from a tanker truck at the Peace Bridge border crossing between New York and Ontario. When an emergency clean-up crew arrived on the scene, they feared they were too late to catch the spill before it fouled local waterways. The response crew ran fire hoses to flush out whatever remained of the spilled fuel from the storm drains for diversion into a make-shift containment area, but no fuel was found. The crew searched downstream for evidence of the spill, but still failed to find even a trace. Eventually, a crew member popped open a manhole, and discovered a Stormceptor inside. The Stormceptor had intercepted the entire spill and stored it safely off-line in its containment tank, despite that section of storm drain having been flushed with fire hoses.

**The Stormceptor had intercepted the entire spill and stored it safely off-line...**

As a result of this incident all new Stormceptors come with specially marked manhole covers for easy identification.

The company that sells Stormceptors, Stormceptor Corporation, believes that within a few years, insurance premiums for gas stations and certain other industries at high risk for generating hazardous spills will drop. They note precedents in other devices effective at reducing liability risk, and believe that it's just a matter of time until premiums are lowered, as the device gains wider acceptance. If this happens, Stormceptors would likely become the first BMP type to not only pay for itself, but actually save the site owner money over the long term.

**Bio-retention**

Created in Prince George’s County, Maryland, this new type of BMP is an update of the infiltration trench, an early BMP type that has been around since the 1970s. The idea behind both the infiltration trench and the bio-retention stand is to divert stormwater.

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**How Three “Next Generation” BMPs Stack Up: Cost, Application, & Performance.**

<table>
<thead>
<tr>
<th></th>
<th>Stormceptor</th>
<th>Bio-retention</th>
<th>Sand Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Cost</td>
<td>Low to moderate</td>
<td>Low to high (depends on soil type)</td>
<td>High</td>
</tr>
<tr>
<td>Maintenance Cost</td>
<td>Low</td>
<td>Usually low</td>
<td>High</td>
</tr>
<tr>
<td>Applicability</td>
<td>Anywhere urban or suburban</td>
<td>Limited by soils</td>
<td>urban sites with rolling terrain</td>
</tr>
<tr>
<td>Phosphorous Removal Efficiency</td>
<td>Good 35 - 50%</td>
<td>Very good 45 - 70%</td>
<td>Good 35 - 70%</td>
</tr>
<tr>
<td>Nitrogen Removal</td>
<td>Poor</td>
<td>Fair</td>
<td>Good, only if designed for this goal</td>
</tr>
<tr>
<td>Oil &amp; Grease Removal</td>
<td>Excellent (~95%)</td>
<td>Not recommended</td>
<td>Some (varies)</td>
</tr>
<tr>
<td>Sediment Removal</td>
<td>Very good</td>
<td>Very good</td>
<td>Not recommended</td>
</tr>
<tr>
<td>Heat Pollution Removal</td>
<td>None</td>
<td>Very good</td>
<td>Good</td>
</tr>
</tbody>
</table>

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Continued on Page 3. See BMPs.
BMPs, from Page 2

runoff to an area of groundwater recharge. The infiltration trench encourages recharge (diversion to groundwater) by providing a properly sized and carefully designed gravel pad at the downslope end of a developed site.

During the 1980s, research showed that these facilities required less maintenance and provided improved pollutant removal efficiencies when combined with 10 to 20-foot vegetated buffer strips. The bio-retention stand goes this idea one better — placing the vegetated buffer strip on top of the infiltration trench. In fact, plantings are carefully selected to nurture the ideal micro-environment for maximizing pollutant removal from stormwater runoff.

One criticism of the infiltration trench is that few nutrients are truly removed from the environment. Critics argue that most pollutants were merely diverted from the surface water to the groundwater. With bio-retention, nutrient uptake from the plantings effectively removes much of the phosphorus and even some nitrogen from the system. And, nearly all of the heat pollution that typifies parking lot runoff is removed.

Bio-retention is cheap, effective, and versatile. Its only serious drawback is its unsuitability for areas underlain with slow-draining, clay-dominant soils. Because bio-retention is only appropriate for sandy and loamy soils, it is a poor choice for most of the Four Mile Run watershed. Continued research is needed to see if soil re-conditioning can reasonably extend the utility of this promising new BMP.

Sand Filters

First used in Austin, Texas, then modified for use in Delaware and Washington, DC, sand filter BMPs are now becoming commonplace in Alexandria, where several varieties exist.

The design most commonly employed in Washington, DC is a compartmentalized underground vault. Storm runoff, usually from parking lots enters a baffled compartment designed to capture trash, heavy sediments, and floating pollutants, including some oil and grease. Water velocity and energy is also slowed here, allowing for controlled flow to enter into the second chamber. This partition contains a carefully designed sand filter, often with separate layers of aggregate, sand, filter fabric, and sometimes pea gravel. A perforated underdrain (pipe) allows the cleaned water to leave the system. Sand filters are promising technology that can deliver impressive pollutant removal rates. On the downside, they are expensive to build and maintain, and require a minimum of three feet of head (vertical distance between the inlet and the outlet); additionally, some may clog prematurely.

Yucky Stuff We Found in the Stream

by Don Weges

On June 8, a team from Friends participated in the annual clean-up of Four Mile Run sponsored by Arlington County Parks. Here's what we removed from the stream:

- a car battery
- a transmission
- a tailpipe
- several car tires
- hubcaps
- a roof gutter
- a bike frame
- a big steel plate (the kind that temporarily covers highway repairs)
- numerous plastic grocery bags
- countless fast-food cups, wrappers, and containers
- lots of other stuff that doesn't belong in streams.

Enter Our Logo Contest!

Submit your entry for the Friends of Four Mile Run logo and win a free three-year membership ($75.00 value). Three winners will receive one-year memberships. All entries will become the property of Friends of Four Mile Run. Deadline: December 31, 1996.

Submissions should be sent to:

Friends of Four Mile Run
3519 Wood Vicet Cl
Fairfax, VA 22032-4018
WHY YOU SHOULD BE CHOOSING STORMCEPTOR AS YOUR URBAN WATER QUALITY DEVICE

Design Flexibility - Stormceptor can be used in situations where no other device will work. Examples are very shallow installations (2.0 surface to invert) and very deep installations (30 feet). No loss in storage capacity or treatment rate when larger storm drains are used, unlike other local separators.

Structural Integrity - Stormceptor is designed to withstand H-20 loading for shallow and deep installations. Unlike other local separators that use thin wall design, which limits use and requires careful and precise backfilling, the Stormceptor is designed for rugged installation abuse.

Cost/Ease of Maintenance - Most separators require maintenance 3 to 6 times a year and physical entry into confined space is required. Stormceptor generally will require maintenance only once per year and confined space entry is not required. Cost of maintenance is about a 1/3 to an 1/8 of other separator devices.

Compatibility with Existing & New Storm Drains - Stormceptor can be used on existing storm drains and new storm drain lines. Stormceptor nearly eliminates the need to impact existing infrastructure features.

Time/Ease of Installation per Acre Treated - Stormceptor can be installed in a hour and operational in two or three hours.

Oil Removal Performance, Long Term - Stormceptor has documented test results to demonstrate its reliability to remove high percentages (>95%) of free oil and grease. No need to replace expensive absorbent pillows as required in other separators.

TSS Removal Performance, Long Term - Stormceptor has documented test results to demonstrate its reliability to remove high percentages (80%) of sediment and solids (TSS).

Guarantee - Stormceptor is backed by one of the largest concrete company’s (CSR) in the world. Our local competitor publishes a “Disclaimer” statement, which says they provide, “no warranties, expressed or implied, for merchantability of fitness for any particular purpose or application.”

Cost - Stormceptor is the least costly to plan, design, secure approvals, construct, operate and maintain and the most reliable urban water quality device available.

Stormceptor - THE SOLUTION TO URBAN POLLUTION
Your Best Choice For Urban Water Quality Control
W Timari
Pavement Grease & Oil
Waterless Cleaner
Honolulu, David Buck
Distributor/Manufacturers Literature
January 2, 1997

Experie P. Dushell, MCP
Project Coordinator
Steel Conference Chairman
1314 South King St., Suite 951
Honolulu, HI 96814

Dear Eugene,

First of all, I would like to thank you for supplying us with a copy of your Management & Implementation Plan for the Ala Wai Canal Watershed Water Quality Improvement Project. It seems to be a very comprehensive compilation of the problems that are currently regarding the canal.

It was a pleasure speaking on the phone with you and I apologize that this information fell off, but I have been somewhat sidetracked during the Holiday Season! I hope you are enjoying it. However, in this packet, I have enclosed some information on our NEWFACt KLEEN GREEN products. In addition, I have enclosed some references and testimonials of some of the patrons that have either bought our products or that we have cleaned. My colleague, Loch Figgia, passed on the same information to Clyde Menza.

Hopefully, you can work on your report to make 1998 a monumental year and restructure some of the problems that plague the Ala Wai Canal Watershed area. If you have any questions, feel free to call me at 523-0008.

Sincerely,

David Beck
NEWFACE when used on concrete and asphalt surfaces will accent the oil leaked by vehicles and give your concrete a brand new appearance by leaving a protective coating that looks like new concrete and that will keep new oil deposits from penetrating into your concrete.

NEWFACE removes fresh and built-up, dried out, oil stains on asphalt and concrete in a matter of seconds leaving a clean, non-tracking surface behind.

NEWFACE is made of 100% inert materials, contains no chemicals is safe for your employees, works on any type of liquid spill and is non-flammable.

NEWFACE has a patented process in its manufacturing making it the only product of its kind in the world.

Please Call TIMARI TRADING COMPANY, at (800) 323-0088 to arrange for a representative to give you a demonstration that will enlighten your thinking on how to clean concrete and asphalt surfaces. Step into the 21st century with a new revolutionary product.
V. HEALTH HAZARDS A. Summary / Risks

SUMMARY: This NEW FACE product contains a small quantity of crystalline silica quartz (less than 0.1% and in the product dust <45 microns), the concern is below XRD detection limit of 0.07%. See Section 11: OSHA considers NEWFACE to be a nuisance dust and concludes NEWFACE is nontoxic.

NEWFACE has not been listed as a carcinogen by the National Toxicology Program or OSHA.

Medical Conditions Which May Be Aggravated: Presuming upper respiratory and lung disease (such as bronchitis, emphysema, asthma or others).

Target Organ(s): Lung Primary Entry Route(s): Inhalation

Acute Health Effects: Temporary upper respiratory irritation.

Chronic Health Effects: Inhalation of high levels of any nuisance dust over long periods of time may overload lung clearance mechanisms and make lung more vulnerable to respiratory disease and affect lung capacity.

V. HEALTH HAZARDS B. Signs/Symptoms of Overexposure

Inhalation: Coughing, irritation of nose and throat; congestion may occur upon overexposure.

Skin Contact: N/A

Skin Absorption: N/A

Ingestion: Not hazardous. Generally regarded as safe by the FDA.

Eye: Temporary irritation and/or inflammation.

V. HEALTH HAZARDS C. First Aid / Emergency Procedures

Inhalation: Remove from dusty area; drink water to clear throat; blow nose to evacuate dust.

Skin Contact: N/A

Skin Absorption: N/A

Ingestion: N/A

Eye: Do not rub eyes. Flush eyes with copious amounts of water to remove any dust particles. Consult a physician if irritation persists.

VI. REACTIVITY DATA

Stability: Material is stable. Hazardous polymerization will not occur.

Chemical Incompatibility: None

Conditions to Avoid: None

Hazardous Decomposition Products: React with hydrofluoric acid to form toxic silicon tetrafluoride gas.

VII. SPILL OR LEAK PROCEDURES

Procedures for Spill/Leak: Vacuum, close, or sweep.

Waste Management: Not considered as hazardous waste by RCRA (40 CFR Part 261).

Place waste and spillage in closed containers. Dispose in approved landfill. RQ-N/A.

VIII. SPECIAL PROTECTION INFORMATION

Goggles: "Normal wear", may use safety eyewear to protect from dust.

Gloves: "Normal wear", may use gloves to protect overly sensitive skin.

Respirator: Is not necessary. Pretending upper respiratory conditions may use dust mask to protect lungs from dust inhalation.

Special Consideration for Repair/maintenance of Contaminated Equipment: Insure proper respiratory protection.

IX. SPECIAL PRECAUTIONS

Storage Segregation: Hazardous Classes: N/A

*** ALWAYS SEGREGATE MATERIALS BY MAJOR HAZARD CLASS ***

Special Handling/Storage: Store in a dry place. Repair all broken bags immediately.

Color: Comply with all Federal, State and Local regulations.

Submitted By: Patrick J. Murphy Title: President

As of the date of preparation of this document, the foregoing information is believed to be accurate and is provided in good faith to comply with applicable Federal and State laws. However, no warranty or representation with respect to such information is intended or given.
Material Safety Data Sheet

NEWFACE ABSORBENT DEEP CLEANING INSTRUCTIONS FOR CONCRETE AND ASPHALT

1. APPLY KLEEN GREEN DEGREASER TO OIL SPOT AT A MIXTURE OF 5 TO 1 WITH WATER FOR CONCRETE AND 10 TO 1 FOR ASPHALT.

2. SCRUB KLEEN GREEN INTO OIL SPOT WITH A STRONG BRISTLED BROOM TURNING OLD SOLIDIFIED OIL BACK INTO A LIQUID NEWFACE CAN EXTRACT.

3. AFTER OIL HAS BEEN LIQUEFIED APPLY GENEROUS AMOUNT OF NEWFACE ABSORBENT TO AREA AND WORK ABSORBENT INTO THE CONCRETE BY SWEeping IT INTO SPILL WITH YOUR BROOM. SWEEP UP EXCESS ABSORBENT PUT IN CAN OR BUCKET AND REUSE ON YOUR NEXT AREA.

4. THE RESULTS ARE A CLEAN PARKING SPACE THAT LOOKS LIKE NEW AS WELL. THEN PROTECTIVE COATING IS APPLIED. ABSORBENT IS DOWN IN THE DOWNS FOR YOUR CONCRETE READY TO ABSORB ANY FROM THE NEXT LEAKY CAR. ASPHALT SURFACES CAN BE RINSED WITH NEWFACE.
Technical Bulletin

KLEEN GREEN

NO. 506
ALL PURPOSE CLEANING COMPOUND

DESCRIPTION: Kleen Green was developed to do a cleaning job on any type of soil or grease. It is a liquid concentrated alkali, light green or yellow in color. It is a very fast cleaner. It may be used in hot or cold water.

METHOD OF USE: Kleen Green may be used as a concentration of 1 to 25 parts water, depending on the amount of soil you are cleaning. It may be used as a wax stripper as full concentration. It may be used for cleaning machinery, by spraying at a concentration of 4 to 1. Then wipe off with a wet rag. For cleaning concrete floors use at 4 to 12 to 1 concentration. For asphalt parking spaces use at 20 to 20 to 1 concentration. For washing walls mix with 5 to 10 parts water. It is excellent for cleaning aluminum pans, as it contains carbonPoor found in motor oils. It will clean white wall tires and plastic seal covers.

SAFETY FACTOR: Kleen Green is non-toxic, non-flammable and non-corrosive. It is odorless, and will not injure workers. It may be dispersed by chopping in the river. It will bleach painted surfaces if used as full concentration.

PACKED: 15 GALLON DRUM
3 GALLON PAINT
4 GALLON CASE

TIMARI TRADING COMPANY LTD.
NEW FACE PRICE LIST AS OF 7/1/1997

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>CONTAINER</th>
<th>QUANTITY</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEW FACE ABSORBENT</td>
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<td>1-2 BOXES</td>
<td>$44.55/EAC</td>
</tr>
<tr>
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<td>4-11 BOXES</td>
<td>$39.95/EAC</td>
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<tr>
<td>NEW FACE ABSORBENT</td>
<td>INDUSTRIAL</td>
<td>12-49 BOXES</td>
<td>$35.95/EAC</td>
</tr>
<tr>
<td>NEW FACE ABSORBENT</td>
<td>INDUSTRIAL</td>
<td>50+ BOXES</td>
<td>$33.95/EAC</td>
</tr>
<tr>
<td>KLEEN GREEN A.P.C.</td>
<td>1 GALLON</td>
<td>1</td>
<td>$24.95/GALLO</td>
</tr>
<tr>
<td>KLEEN GREEN A.P.C.</td>
<td>4 GALLON CASE</td>
<td>4</td>
<td>$23.95/GALLO</td>
</tr>
<tr>
<td>KLEEN GREEN A.P.C.</td>
<td>5 GALLON BUCKET</td>
<td>1</td>
<td>$19.95/GALLO</td>
</tr>
<tr>
<td>KLEEN GREEN A.P.C.</td>
<td>5 GALLON BUCKET</td>
<td>4+</td>
<td>$17.95/GALLO</td>
</tr>
<tr>
<td>KLEEN GREEN A.P.C.</td>
<td>45 GALLON DRUM</td>
<td>1</td>
<td>$15.95/GALLO</td>
</tr>
<tr>
<td>CONCRETE BROOM</td>
<td>14 INCH HEAD</td>
<td>1</td>
<td>$21.95/EAC</td>
</tr>
<tr>
<td>NEW FACE SPRAYER</td>
<td>2.5 GAL. PUMP SPRAYER</td>
<td>1</td>
<td>$55.95/EAC</td>
</tr>
</tbody>
</table>

FOR ADDITIONAL INFORMATION ON TIMARI TRADING COMPANY PRODUCTS CALL 523-7408

Outer Islands (808) 914-9815
January 3, 1997

Mr. Mark Buck
Timani Trading Company Ltd.
P.O. Box 1358
Honolulu, Hawaii 96807

Dear Mr. Buck,

Thank you for a job well done here at the First Insurance Building. I was concerned when the cleaning of the parking structure had to be scheduled for completion in one weekend. As you know the parking structure here has not been done in quite a while and the lighting level that exists makes the job even more difficult. What a pleasure it was to come in on Monday to find the project completed. It was also a pleasure to inspect the work and discover there was no need for your crew to return to complete a punchlist. Your company's desire and ability to do quality work is evident. Also the product used by your company is an excellent job of lifting the stains in the parking stalls.

Once again thank you for delivering the results you committed to along the timeline we required.

Sincerely,

Chaney Brooks and Company

Michael Lantry
Chief Engineer
First Insurance Building

January 9, 1997

Mr. Mark Beck
Timani Trading Company
P.O. Box 1358
Honolulu, Hawaii 96807

Dear Mark,

We are very pleased with the result of your cleaning of First Hawaiian Bank parking structure. As you are well aware, our facility has 400 concrete surface parking stalls on multiple levels onto 10 stories, covering 117,385 square feet. Your company was chosen because of your competitive price and your cleaning product Absorb/Clone Green. We were looking for an alternative to the standard steam cleaning method that will only wash off the top layer of oil and grease but don't get down deep. Also of great concern was not having the removed oil and grease washed down the drains and into the ocean.

Your cleaning method, products and diligent personnel cleaned our dirty, oozing surface so that they were like fresh poured concrete once again, but yet left the painted wall markings unaffected.

You and your personnel showed us at First Hawaiian Bank that Timani Trading Company has the ability to plan, coordinate and execute a complex cleaning project despite terrible weather, interference from other contractors and incoming/existing vehicles.

Mahalo,

Ralph O. Hersh
Chief Engineer
First Hawaiian Bank
Kapiolani University Center
**Unusual Fire & Explosion Hazards:** NONE

**Note:** Under normal conditions hazardous polymerization will not occur.

**Section VI**

**Physical Data**

- **Boiling Point:** 212
- **Specific Gravity (Water = 1):** 1.06
- **Vapor Pressure:** N/A
- **Vapor Density:** H/A
- **Percentage Of Volatiles:**
- **Evaporation Rate (Water = 1):** 1.03
- **Ph (Concentrate):** 13.2
- **Ph (1% Solution):** 13.3

**Solubility In Water:** THIS PRODUCT IS 100% SOLUBLE IN WATER.

**Appearance and Odor:** CLEAR GREENISH/YELLOW LIQUID WITH A BLAND ODOR.

**Section VII**

**Special Precautions**

- Respiratory Protection: NONE
- **Protective Gloves:** NONE
- **Eye Protection:** When handling this product and there is the possibility of splashing it is recommended that proper protection of the eyes be worn.

**Other:** NONE

**Equipment:** NONE

**Note:** This data is furnished gratuitously independent of sale of the product and only for your investigation and independent verification. While data is believed to be correct, SHIP CHEMICAL shall in no event be responsible for damages whatsoever, direct or indirect, resulting from the publication or use of or reliance upon data contained herein. No warranty, either implied or expressed, of merchantability or fitness or of any nature with respect to the product or to the data is made herein. You are urged to obtain data sheets for all chemicals you buy, process, use, or distribute, and are encouraged to advise anyone working with or exposed to such materials of the information contained herein.

**Sources:**

1. **Dangerous Properties of Industrial Materials:** Ems, 6th Ed.
2. **Handbook of Toxic and Hazardous Chemicals and Carcinogens:** 2nd Ed.
3. **Concise Chemical Dictionary:** Weast, 7th Edition
4. **TLV's and Biological Exposure Indices for 1985-86:** ACGIH, 2nd ed.
5. **Directorate List of Hazardous Substances:** State of Calif, 1st Printing
6. **Title 49 CFR Parts 170 to 171:** Revised as of July 1, 1984
7. **Documentation of TLV's and BEI's:** ACGIH, Fifth Edition
8. **Guidelines for the Selection of Chemical Protective Clothing:** ACGIH, 5th Printing
9. **Emergency Response Guidebook:** Department of Transportation, 1984 ed