Appendix D
Seattle DWU Data

City of Seattle

Norman B. Rice, Mayor
Seattle Public Utilities
Diana Gale, Director

RECEIVED
FEB 10 1997
Capital Projects Division

MEMORANDUM

DATE: February 7, 1997

TO: Priscilla Hackney. King County Department of Natural Resources

FROM: Cheryl Paston, Seattle Public Utilities

SUBJECT: Duwamish/Diagonal Sediment Remediation Project

Attached is the information that Tom Belnick of EcoChem requested that we supply for the above project in a memo dated January 16, 1997.

1. Tabulated results for the Diagonal drainage basin business inspections. There are two tables, one showing those businesses that have already been inspected and the other showing those still needing inspections. We sent EcoChem a list of the SIC codes as an attachment to the summary of businesses we inspected in the Norfolk drainage basin.

2. Short summary of the investigation to date of the oily water discharge from the Diagonal stormdrain.

3. Copy of the report discussing the City's SWM model for the Diagonal basin.

He also wanted an update on the cleaning of the sediment in the Diagonal stormdrain. It has not been scheduled to be cleaned yet. We are in the process of getting some cost estimates from several contractors for removing the sediment. We hope to schedule it as close as possible to when King County conducts the sediment cleanup at the end of the outfall.

If you need further information, please call me at 684-4609. Thank you.

Dexter Horton Building, 10th floor 710 Second Avenue, Seattle WA 98104
Tel: (206) 684-5851, TTY/TDD (206) 233-7241, FAX: (206) 684-4631
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Diagonal Basin: Completed Business Investigations

Business	Address	Visit	Comments	SIC	DESCRIPTION
90-5 Deli	2203 Airport Way S	Drive by	No outside activity.	5812	Eating places
Access Electric Supply	2010 Airport Way S	Drive by	No outside activity.	5063	Electrical apparatus & eq
Acco Chain & Lifting Product	2203 Airport Way S # 612	Drive by	No outside activity.	9999	Unidentified
Active Singles Life	3450 6th Ave S	Drive by	No outside activity.	2711	Newspapers
Ad-Post Northwest Inc	3450 6th Ave S	Drive by	No outside activity.	7311	Advertising agencies
Adhesa-Plate Manufacturing	4000 7th Ave S	Drive by	No outside activity.	3993	Signs & advertising
Adolfo's Italian Restaurant	3924 Airport Way S	Drive by	No outside activity.	5812	Eating places
Air Filter Sales???	2505 Airport Way S	Drive by	No outside activity.	5231	Paint, glass, wall paper st
Air System Engineering	3429 Airport Way S	Drive by	No outside activity.	1711	Plumbing, heating, air con
Alaska Railroad Corp	2203 Airport Way S # 215	Drive by	No outside activity.	4011	Railroad line haul operati
Alaskan Copper & Brass Co	3223 6th Ave S	Inspection	Big, busy metal yard. Well run, tidy.	5088	Transportation equip & su
America Windshields	4101 Airport Way S	Inspection	Windshield repair. No flluids on-site. Occaisonal vehicle washing.	5231	Paint, glass, wall paper st
American Banner & Sign Co	637 S Industrial Way	Drive by	No outside activity.	3993	Signs & advertising
American Trailer Repair Co	2535 Airport Way S	Inspection	Impressive. Clean. No oustide work or storage.	7538	General auto repair
Ann Welch	707 S Snoqualmie St	Drive by	No outside activity.	3229	Pressed or blown glass mf
Aurora Crane	3400 6th Ave S	Combined	Large, oily yard. Combined system.	5012	Automotive mobiles & ve
Auto Parts Distributing Co	4107 Airport Way S	Drive by	Retail/wholesale. No outside activity. No fluids.	5013	Motor vehicle supplies &
Auto Parts Warehouse Inc	4400 4th Ave S	Drive by	No outside activity.	5531	Auto & home supply stor

Business	Address	Visit	Comments	SIC	DESCRIPTION
Auto-Mobile Auto & Truck R	4556 14th Ave S	Drive by	Resident Business	7538	General auto repair
Bader & Olson Inc	4143 1st Ave S	Drive by	No outside activity.	7389	Business services, other
Barclay Dean Architectural Pr	4623 7th Ave.	Inspection	Mostly contractor for indoor sheet rock/partitions.	9999	Unidentified
Barr Automatic Transmission	3913 Airport Way S	Combined	Combined line.	7538	General auto repair
Bearing Engineering & Suppl	2548 Airport Way S	Drive by	No outside activity.	9999	Unidentified
Benson Phelps	620 S Spokane St	Drive by	No outside activity.	3569	General industrial machin
Better Edge Of Washington	2916 Beacon Ave S	Drive by	No o/s Activity	7692	Welding repair shops
Blanchard Auto Electric Co	3232 8th Ave S	Out of bus	Vacant building. Blanchard moved to 640 Spokane St.	7539	Auto repair, other
Bmp Inc	647 S Alaska St	Drive by	No outside activity.	1721	Painting
Boston Hardwood Floors	4529 15th Ave S	Drive by	No o/s Activity	1752	Floor laying
Breathing Apparatus Repair S	630 S Nevada St	Drive by	No outside activity.	5063	Electrical apparatus & eq
Breyers Ice Cream	3619 7th Ave S	Drive by	No outside activity.	5143	Dairy products, w/s
Brezak Berries	651 S Industrial Way	Inspection	See Seasia. Same address.	9999	Unidentified
Burlington Environmental	2203 Airport Way S # 400	Drive by	No outside activity.	4953	Refuse system (dumps, in
CABEGIN MANNY E & NO	1741 S Hanford St #5	Drive by	Resident Business	4121	Taxi cabs
Carl Compton Inc	4143 1st Ave S	Drive by	No outside activity.	4213	Trucking, not local
Central Engine & Machine Co	610 S Alaska St	Drive by	No outside activity.	5015	Motor vehicles parts, used
Charter Construction Inc	1900 Airport Way S	Drive by	No outside activity.	1521	Residential Construction
CHAUDHRI JAIRAJ S	4523 13th Ave S	Drive by	Resident Business	4121	Taxi cabs
CHEN SHUO Y	1723 13th Ave S # 304	Combined		2711	Newspapers
Chuck Pillon & Assoc Inc	3619 7th Ave S	Drive by	No outside activity.	8071	Medical labs

Business	Address	Visit	Comments	SIC	DESCRIPTION
City Moving Systems	4500 4th Ave S	Drive by	No outside activity.	4214	Trucking, local with stora
Co-Op Shippers Inc	5050 1st Ave S	Drive by	No outside activity.	4213	Trucking, not local
Color Design Exhibits Inc	2015 Airport Way S	Drive by	No outside activity.	7319	Advertising, NEC
Commercial Warehouse Co	3623 6th Ave S	Drive by	Duplicate. See Owl Storage same address.	4225	General warehouse & stor
Consolidated Press Printing C	600 S Spokane St	Drive by	No o/s Activity	2711	Newspapers
Cossack Caviar Inc	101 S Dakota St	Drive by	No outside activity.	2091	Fish, canned & cured
Craftsmen Ltd	5035 1st Ave S	Drive by	No outside activity.	2599	Furniture, other
Crosscut Hardwoods	4100 1st Ave S	Drive by	No outside activity.	5211	Lumber & building materi
Custom Wire Products	3427 Airport Way S	Drive by	No outside activity.	5051	Metals service centers W/
Daniel Smith	4130 1st Ave S	Drive by	No outside activity.	5999	Misc. retail
David R Huchthausen	3911 Airport Way S	Drive by	No outside activity.	8999	Services, other
Devoe Marine Coatings	3623 6th Ave S	Out of bus	See Owl Transfer and Storage. Same address.	3479	Coating, engraving, other
Diesel Service Co	3429 Airport Way S	Drive by	No outside activity.	7538	General auto repair
Dinner & Klein	600 S Spokane St	Drive by	No outside activity.	7331	Direct mailing service
Direct Mail Design Inc	707 S Snoqualmie St	Drive by	No outside activity.	2741	Misc. publishing
Distributor's Warehouse Tba	3901 Airport Way S	Drive by	No outside activity.	5014	Tires & tubes W/S
Drexco Leasing Co	2100 Airport Way S	Drive by	No outside activity.	3599	Industr & commercial ma
Dri-Tech	3210 Beacon Ave S	Drive by	Out of Business	5087	Service establishment equ
Ecos	2203 Airport Way S	Drive by	No outside activity.	9999	Unidentified
Elo's Philly Grill	3433 Airport Way S	Drive by	No outside activity.	5812	Eating places
Emerald City Bindery	4809 Airport Way S	Drive by	No outside activity.	2789	Bookbinding
Empire States Transport	2326 Airport Way S	Drive by	No outside activity.	4213	Trucking, not local

Business	Address	Visit	Comments	SIC	DESCRIPTION
Ena Couriers Inc	2 S Horton St	Drive by	No outside activity.	4212	Trucking, local without st
Eternity Lounge & Restaurant	4005 Airport Way S	Drive by	No outside activity.	5812	Eating places
Fabriform Plastics Inc	3300 Airport Way S	Combined	Combined line.	3089	Plastic products, other
First Line Plastics Inc	636 S Alaska St	Drive by	No outside activity. Wholesale.	2673	Bags: uncoated paper, mf
Flint Ink Corp	655 S Andover St	Drive by	No outside activity.	2893	Printing ink mfg
Fluckinger Machine Works	4800 Airport Way S	Drive by	No outside activity.	3599	Industr & commercial ma
Gasoline Tank Svc Inc	2203 Airport Way S # 400	Drive by	No outside activity.	4213	Trucking, not local
Ge Medical Systems	700 S Industrial Way	Drive by	No outside activity.	9999	Unidentified
Gel Ice Zero-Pak	101 S Dakota St	Drive by	No outside activity.	5999	Misc. retail
Genelex Corp	2203 Airport Way S	Drive by	No outside activity.	8071	Medical labs
Gretchen's Of Course	2415 Airport Way S	Inspection	Clean/tidy establishment. On-site fleet washing.	5812	Eating places
Hadco Supply	2203 Airport Way S # 801	Drive by	No outside activity.	1711	Plumbing, heating, air con
Hamilton Custom Press Inc	3706 Airport Way S	Combined	Combined line.	2752	Commercial printing - lit
Hamilton, William	3706 Airport Way S	Combined	Combined line.	4213	Trucking, not local
Huntley Machine & Tool Co	4623 7th Ave S	Drive by	No outside activity.	3599	Industr & commercial ma
Hydroceramic Co	4025 7th Ave S	Drive by	No outside activity.	4952	Sewerage systems
I'Anson Chain Co	820 S Bradford St	Drive by	No storm connection. Runoff infiltrates into ground.	9999	Unidentified
Impact Direct	3315 Beacon Ave S	Drive by	No o/s Activity	7331	Direct mailing service
Insurance Courier Svc	4001 1st Ave S	Drive by	No outside activity.	4212	Trucking, local without st
International Products	601 S Andover St	Drive by	No outside activity.	2673	Bags: uncoated paper, mf
International Video	3207 1/2 Beacon Ave S	Drive by	No o/s Activity	7622	Radio & tv repair

Business	Address	Visit	Comments	SIC	DESCRIPTION
Inx Intl Ink Co	4029 1st Ave S	Drive by	No outside activity.	2893	Printing ink mfg
J R Abbott Construction Co	3512 Airport Way S	Combined	Combined line.	1542	Non residential, non indus
Jobbers Service Co	510 S Industrial Way	Drive by	No outside activity.	5261	Retail nursery and garden
John Latta Assoc Inc	4621 Airport Way S	Drive by	No outside activity.	5032	Brick, stone, etc W/S
Kaman Bearing & Supply	2203 Airport Way S	Drive by	No outside activity.	5085	Industrial supplies, other
Karen Guzak Studio	707 S Snoqualmie St # 5a	Drive by	No outside activity.	8999	Services, other
Kustom Foods	651 S Industrial Way	Inspection	See Seasia. Same address.	5141	Groceries, general W/S
L & W Food Corp	923 S Bayview St	Drive by	No outside activity.	5099	Durable goods, other W/S
L N Curtis & Sons	629 S Industrial Way	Drive by	No outside activity.	5063	Electrical apparatus & eq
Laforge Corporation	4601 Diagonal Way	Inspection	Inspection	5032	Brick, stone, etc W/S
LEM SUSANNE Y	4142 12th Ave S	Drive by	Resident Business	2299	Textile goods, other
Lennon Packing Co	601 S Nevada St	Drive by	No outside activity.	2013	Sausages & other prepare
Liberty Co.	2535 Airport Way S	Inspection	Diesel & gas. Clean. All drains to storm.	5172	Crude petroleum & produ
Lighting Plastics Northwest	619 S Snoqualmie St	Drive by	No outside activity.	7629	Electrical repair, other
Little Deli Mart	2701 Airport Way S	Drive by	No outside activity.	5812	Eating places
M & R Equipment	3626 Airport Way S	Combined	Combined line.	5084	Industrial machine equip
Mac Donald Meat Co	2709 Airport Way S	Drive by	No outside activity.	5147	Meats & meat products W
Mack Trucks Inc	2025 Airport Way S	Combined	All outside drains connect to sanitary sewer. No storm lines in the area.	5511	Motor vehicle dealers (ne
Maintenance-Janitorial	2203 Airport Way S # 803	Drive by	No outside activity.	5087	Service establishment equ
Mamon & Mamon	3215 Lafayette Ave	Drive by	Resident Business	5093	Scrap & Waste Materials
Masters Guild Plumbing	3819 13th Ave S	Drive by	Resident Business	1711	Plumbing, heating, air con

Business	Address	Visit	Comments	SIC	DESCRIPTION
Mc Lean-Hungar Assoc Inc	3623 6th Ave S	Out of bus	See Owl Transfer & Storage. Same address.	5046	Commercial equipment, o
Mc Sweeney Steel Co	2326 Airport Way S	Drive by	No outside activity.	5051	Metals service centers W/
Mer'Con Inc	4101 12th Ave S	Drive by	Resident Business	1521	Residential Construction
Milke, Tesgaye	3440 14th Ave S # 105	Drive by	Resident Business	4121	Taxi cabs
Milwaukee Electric Tool Corp	5419 Maynard Ave S	Drive by	No outside activity.	5084	Industrial machine equip
Mobile Equipment Systems	2120 Airport Way S	Drive by	No outside activity.	5013	Motor vehicle supplies &
Motor Parts Mach Co	2100 Airport Way S	Drive by	No outside activity.	5013	Motor vehicle supplies &
Nancy Hammer Landscape De	707 S Snoqualmie St # 5d	Drive by	No outside activity.	781	Landscape counseling &
Nemco Electric Co	207 S Horton St	Drive by	No outside activity.	3646	Commercial lighting fixtu
Neway Packaging Corp	3429 Airport Way S	Drive by	No outside activity.	5084	Industrial machine equip
Ngoc Vinh Jewelry	2516 Beacon Ave S	Combined		3911	Jewelry & precious metal
North Star Casteel Products	820 S Bradford St	Drive by	No connect. to storm. Runoff infiltrates.	3325	Steel foundries, other
Northwest Bus Sales Inc	3400 6th Ave S	Out of bus	Out of business. See Aurora Crane	5511	Motor vehicle dealers (ne
Northwest Dyeworks Inc.	4505 Airport Way S	Inspection	New business under construction.	5012	Automotive mobiles & ve
Northwest Forklift Inc	4429 Airport Way S	Out of bus	Property is for rent.	5084	Industrial machine equip
Northwest Marketing Systems	4500 4th Ave S	Drive by	No outside activity.	5085	Industrial supplies, other
Northwest Plating Co	825 S Dakota St	Drive by	No outside activity.	3471	Plating & polishing
Northwest Services Co	610 S Alaska St	Drive by	No outside activity.	5013	Motor vehicle supplies &
Northwest Structures Inc	4000 Airport Way S	Drive by	Out of business.	1542	Non residential, non indus
Oak Floors Of Greenbank Inc	3217 Airport Way S	Drive by	No outside activity. Outside area is combined.	1752	Floor laying

Business	Address	Visit	Comments	SIC	DESCRIPTION
Ocs Seattle	1900 Airport Way S	Drive by	No outside activity.	4513	Air courier services
Ogata, Patricia	3412 15th Ave S	Drive by	Resident Business	2721	Periodicals
Olshen's Bottle Supply Inc	923 S Bayview St	Drive by	No outside activity.	3221	Glass container mfg
Ostex International Inc	2203 Airport Way S # 301	Drive by	No outside activity.	8731	Physical, biological resear
Oversea Casing Co Inc	4226 6th Ave S	Drive by	No outside activity.	2013	Sausages & other prepare
Owl Transfer & Storage Co	3623 6th Ave S	Inspection	Commercial storage & trucking. Some vehicle washing.	4214	Trucking, local with stora
Pacific Air Cooled Engine	4111 Airport Way S	Out of bus	Vacant building.	5261	Retail nursery and garden
Pacific Coastal Reps Inc	4020 Airport Way S	Drive by	No outside activity.	5099	Durable goods, other W/S
Pacific Edge Int'l Co	2326 Airport Way S	Drive by	No outside activity.	5093	Scrap & Waste Materials
Pacific Edge Marine Equipme	2326 Airport Way S	Drive by	No outside activity.	5085	Industrial supplies, other
Pacific Food Importers	2323 Airport Way S	Inspection	Trucking. Gave tips on fleet maintenance.	5141	Groceries, general W/S
Pacific Protective Garments In	4797 1st Ave S	Drive by	No outside activity.	2262	Textile finishing plants, s
Pacific Steel Housing Corp	2326 Airport Way S	Drive by	No outside activity.	1542	Non residential, non indus
Painters Inc	4501 Airport Way S	Inspection	Paint storage. Many 1 - 5 g buckets. Good work practices. Clean shop.	1721	Painting
Paratex Paramount Pest Contr	423 S Horton St	Drive by	No outside activity.	7342	Disinfection & pest contr
Paul F Munson Pacific Closur	3623 6th Ave S	Out of bus	See Owl Transfer & Storage. Same address.	3221	Glass container mfg
Performance Sign Products	2203 Airport Way S # D80	Drive by	No outside activity.	5063	Electrical apparatus & eq
Performance Warehouse	601 S Alaska St	Drive by	No outside activity.	5013	Motor vehicle supplies &
Pignatelli Rene V	1756 S Spokane St # 304	Drive by	Resident Business	4121	Taxi cabs

Business	Address	Visit	Comments	SIC	DESCRIPTION
Pinkerton's Investigations	2203 Aiport Way S # 115	Drive by	No outside activity.	7381	Detective & armored car s
Plan America Safeway	2910 Airport Way S	Drive by	No outside activity.	9999	Unidentified
Plastics For Lighting Inc	619 S Snoqualmie St	Drive by	No outside activity.	5063	Electrical apparatus & eq
Psi Parts & Svc	3407 Airport Way S	Combined	Fork lift sales & repair company. Combined drainage. Property is below street grade.	5084	Industrial machine equip
Puget Sound Freight Lines	3720 Airport Way S	Combined	Combined line.	4123	Taxi cabs, other
Quality Parts Svc Inc	421 S Hinds St	Drive by	No outside activity.	5013	Motor vehicle supplies &
Quik X Transportation Inc	150 S Horton St	Drive by	No outside activity.	4213	Trucking, not local
Rainier Auto Electric	610 S Alaska St	Drive by	No outside activity.	7538	General auto repair
Rainier Brewing Company	3100 Airport Way So	Drive by	Mostly combined. Separated areas only serve one or two parking lots.	9999	Unidentified
Red Star Yeast & Products	600 S Alaska St	Drive by	No outside activity.	5149	Groceries, other W/S
Refuse Equipment Co	3400 6th Ave S	Out of bus	See Aurora Crane. Same address.	3589	Service industry machines
Resource Recovery Div	2203 Airport Way S # 400	Drive by	No outside activity.	4731	Arrangement of freight &
Richards Brush Mfg Co	3229 Airport Way S	Drive by	No outside activity.	5087	Service establishment equ
Sam's Air Filter Exchange	4600 Corson Ave S	Drive by	Not in basin	5531	Auto & home supply stor
Sam's Tire Svc	3810 Airport Way S	Combined	Combined line	5531	Auto & home supply stor
Sanderson Safety Supply Co	2600 Airport Way S	Drive by	No outside activity.	5099	Durable goods, other W/S
Santa Fe Food Co	2010 Airport Way S	Drive by	No outside activity.	5141	Groceries, general W/S
Sawdust Supply	15 S. Spokane	Inspection	Outdoor storage.	5199	Non durable goods, other
Schoenfeld Neckwear Corp	676 S Industrial Way	Drive by	Out of business.	2323	Men's & Boy's neckware

Business	Address	Visit	Comments	SIC	DESCRIPTION
Seair Express	2203 Airport Way S # 110	Drive by	No outside activity.	4731	Arrangement of freight &
Seaport Express	1900 Airport Way S	Drive by	No outside activity.	4212	Trucking, local without st
Sears Plumbing & Rooter	2507 Beacon Ave S	Combined		7699	Repair, other
Sears Roebuck & Co	4786 1st Ave S	Drive by	No outside activity.	7629	Electrical repair, other
Seasia Wholesale Co	651 S Industrial Way	Inspection	Grocery wholesale and food manuf. Tidy.	5141	Groceries, general W/S
Seattle Auto Glass	665 S Dakota St	Drive by	No outside activity.	5231	Paint, glass, wall paper st
Seattle Factory Warehouse	640 1/2 S Spokane St	Drive by	No outside activity.	5013	Motor vehicle supplies &
Seattle Port Consolidators	2326 Airport Way S	Drive by	No outside activity.	4731	Arrangement of freight &
Seattle Prop & Special Effects	667 S Andover St	Drive by	Out of business.	9999	Unidentified
Seattle Stair & Millwork	647 S Alaska St	Drive by	No outside activity.	1799	Special contractors, other
Shapely, Maura	3320 Beacon Ave S	Drive by	No o/s Activity	2759	Commercial printing othe
SINGH BALWANT	2512 14th Ave S Apt 304	Combined		4121	Taxi cabs
Skyline Electric/Mfg Co	3619 7th Ave S	Drive by	No outside activity.	1711	Plumbing, heating, air con
Solly's Choice Seeds	2755 Airport Way S	Inspection	Wholesale seed co. Has solid fertilizers. Has small fleet.	3441	Fabricated structural meta
Solomon Watch Inc	3205 Beacon Ave S	Drive by	No o/s Activity	7631	Watch, clock, jewelry rep
Star Dental Lab	4364 15th Ave S	Drive by	No o/s Activity	8072	Dental labs
Starbucks Coffee Co	2203 Airport Way S # 650	Drive by	No outside activity.	5499	Misc. food stores
Stusser Electric Co	660 S Andover St	Drive by	No outside activity.	5063	Electrical apparatus & eq
Sunfresh Foods Inc	2010 Airport Way S	Drive by	No outside activity.	9999	Unidentified
TEFERA WONDACHEW E	1303 S Judkins St	Drive by	Resident Business	4121	Taxi cabs
TERNEHE ALEMAYHU	2501 13th Ave S #4	Combined		4121	Taxi cabs

Business	Address	Visit	Comments	SIC	DESCRIPTION
Thomas Scalzo Co	3211 Airport Way S	Drive by	No outside activity. Still in business?	4213	Trucking, not local
TubeArt	2535 Airport Way S	Inspection	Small shop - 1 bay. Works indoors.	7538	General auto repair
Two Swans Restaurant	4005 Airport Way S	Drive by	No outside activity.	5813	Drinking places
Union Manufacturing Co.	620 S Industrial Way	Inspection	New business. Well run, tidy. Some barrels outside.	5999	Misc. retail
United Building Svc	4000 Airport Way S	Drive by	Out of business.	1611	Highway & street constru
United Drain Oil Svc	2203 Airport Way S	Drive by	No outside activity.	5093	Scrap & Waste Materials
United Parts Corp	4126 Airport Way S	Drive by	No outside activity.	5013	Motor vehicle supplies &
Universal Plastics Co	650 S Industrial Way	Drive by	No outside activity.	5162	Plastic materials W/S
Valley Freightliner-Mercedes	2401 Airport Way S	Inspection	Truck repair. Mainly indoors. Good, but room for imprvmnt.	7538	General auto repair
Voice Publishing	3450 6th Ave S	Drive by	No outside activity.	2721	Periodicals
Washington Belt & Drive Syst	4201 Airport Way S	Drive by	No outside activity.	5084	Industrial machine equip
Western Cartage Inc	5050 1st Ave S	Drive by	No outside activity.	4213	Trucking, not local
Western Fleet Supply Inc	620 S Dakota St	Drive by	No outside activity.	5013	Motor vehicle supplies &
Western Steel Casting Co	145 S Horton St	Drive by	No outside activity.	3325	Steel foundries, other
Wiloma Distributors	2203 Airport Way S	Drive by	No outside activity.	9999	Unidentified
Winterscheid & Winterscheid	1316 13th Ave S	Combined		4499	Water transport services,
Yankee Environmental Svc	619 S Alaska St	Drive by	No outside activity.	3443	Fabricated plate work (boi

Diagonal Basin: Businesses needing inspection

Business	Address	SIC Code	Business Type
ABC Towing	710 S Dakota St.	7532	Auto body repair & painting
Ackerley Communications I	3601 6th Ave S	3993	Signs & advertising
Active Gear	600 S Dakota St	5561	Recreation & utility trailer dealers
Al's Seattle Barrel Co	4716 Airport Way S	3412	Metal barrel, drums, pails, mfg
Arctic Overseas Packakging	4800 Denver Ave S	4783	Packing and crating companies
Armadillo Construction	3800 7th Ave -- W side	1541	Industrial construction
Bartel Shipping	4717 Denver Ave S	9999	Unidentified
Bay Carriers Inc	4800 Denver Ave S	9999	Unidentified
Bentley Repair Co	4109 Airport Way S	5261	Retail nursery and garden store
Blanchard Auto Electric Co.	640 S Spokane St	7539	Auto repair, other
Bloch Steel Industries	4580 Colorado Ave S	5051	Metals service centers W/S
Chemical Distributors Inc	22 S Idaho St	5169	Chemical products, other W/S
Coastal Tank Cleaning	6th & Charlestown -- E side	9999	Unidentified
Container Care Intl	1 S Idaho St	4731	Arrangement of freight & cargo t
Details Custom Car Care Pl	2420 Airport Way S	7542	Carwashes
Genco Refrigeration	1 S Idaho St	4731	Arrangement of freight & cargo t
General Welding Supply Co	4413 Airport Way S	5084	Industrial machine equipment W/
George Heiser Body Co	725 S Hanford St	3713	Truck & bus bodies, mfg
George S Schuster Co	12 S Idaho St	5031	Lumber, plywood & wood panels
Gil Corley Co	4717 Denver Ave S	5999	Misc. retail
Hamilton Engine Sales Inc	8 S Idaho St	5531	Auto & home supply stores
Hasbro Incorporated	48 S Nevada St	4225	General warehouse & storage
Honolulu Freight Svc	2326 Airport Way S	4731	Arrangement of freight & cargo t
Jack's Truck Parts	4141 2nd Ave S	7538	General auto repair
Jacks Inc	24 S Idaho St	5085	Industrial supplies, other W/S
Jemco	901 S Hinds St	5012	Automotive mobiles & vehicles,
John Perine Co	820 S Adams St	5072	Hardware W/S

Business	Address	SIC Code	Business Type
Kodiak Supply	1922 Airport Way S	9999	Unidentified
Lee & Eastes Tank Lines In	2418 Airport Way S	4213	Trucking, not local
Metal Goods Svc Ctr	4755 1st Ave S	5051	Metals service centers W/S
Mobile Equipment System	2110 Airport Way S	9999	Unidentified
National Sanitary Supply C	20 S Idaho St	5087	Service establishment equip & su
Net Tooling	4740 Airport Way S	3599	Industr & commercial machines
North Pacific Lumber Co	4800 Denver St S	5211	Lumber & building materials stor
Northwest Pump & Equipm	601 S Snoqualmie St	5084	Industrial machine equipment W/
Oberto Sausage Co	2005 Airport Way S	5421	Meat & fish markets
Oil Express	2420 Airport Way S	7538	General auto repair
Pac Lease-Peterbilt	3707 Airport Way S	7513	Truck rental & leasing
Pacific Trucking	300 S Spokane St	4213	Trucking, not local
Phelps Tire Co	2520 Airport Way S	5531	Auto & home supply stores
Pioneer Metal Finishing Inc	690 S Dakota St	3471	Plating & polishing
Plymouth Poultry Co.	4500 7th Ave. S	5149	Groceries, other W/S
Porbug	820 Charlestown	9999	Unidentified
Pro Express Inc	4800 Denver Ave S	4212	Trucking, local without storage
Puget Sound Industrial Serv	3407 Airport Way S	5014	Tires & tubes W/S
Rail Products & Fabrication	1922 Airport Way S	5088	Transportation equip & supplies
Roadway Express	3300 6th Ave S	4213	Trucking, not local
Seattle Mailing Company	2535 Airport Way S	7692	Welding repair shops
Seattle Produce Terminal	4103 2nd Ave S	5141	Groceries, general W/S
Sharp Automotive	2102 Airport Way S	7538	General auto repair
Steam Supply & Rubber Co	615 S Alaska St	5085	Industrial supplies, other W/S
Sunny Jim	4200 Airport Way S	9999	Unidentified
Svendsen Brokerage	Diagonal S & Colorado S	5146	Fish & Seafood W/S
Total Concrete Svc Inc	618 S Alaska St	1771	Concrete work
Trade-Marx Sign & Display	3614 6th Ave S	3993	Signs & advertising

Business	Address	SIC Code	Business Type
Union Manufacturing Co	4 S Idaho St	3599	Industr & commercial machines
United Commercial Leasing	4141 2nd Ave S	4214	Trucking, local with storage
United Motor Freight Inc	4141 2nd Ave S	4213	Trucking, not local
United Parcel Svc	4455 7th Ave S	4215	Courier services (not air)
Welders Service Inc	2204 Airport Way S	5084	Industrial machine equipment W/
Wilcor Grounding Systems	4045 7th Ave S	3699	Electrical machines, equip, supp
Wpi Refuse Systems	3707 Airport Way S	5064	Electrical appliances, TV & radi

Summary of the City's investigation of oil sheen at the Diagonal Outfall

Feb. 7, 1997

The City and the Coast Guard received notification of an oil sheen discharging from the Diagonal Pipe outfall on 8/2/96. According to reports, an oil sheen was present at low tide and had gotten more noticeable the month before. King County staff, who have recently collected sediment samples in this vicinity, confirmed this report. The oil sheen is still often visible at low tides.

The City and the Coast Guard began to track the source of oil. However, neither party has been able to determine the source. The City and the Coast Guard are continuing to search for the source when tides are favorable. During the summer (1996), the Coast Guard collected a few samples of the oil-contaminated baseflow from the stormdrain. They have been archived but they have not been analyzed yet.

Identifying the source of the oil sheen has been difficult due to a number of factors:

- the size of the basin, (24 square miles)
- the hundreds of possible sources of oil,
- potentially intermittent nature of oil entering the line,
- the effect of tide in blurring the specific source(s)

The tide poses the toughest aspect of tracking the source. An incoming tide may push the oil sheen upstream of its source. To minimize this effect, staff can only track the oil sheen during extremely low tides. However, an observer looking in the pipe at low tide could not tell with certainty whether the source of the observed oil was upstream or downstream of his location.

City and Coast Guard staff observed the following:

- At low tide, an oil sheen could consistently be found along the mainline between the river and Airport Way.
- Between Airport Way and the Hanford tunnel, the sheen was intermittent.
- The oil sheen was not seen upstream of the Hanford tunnel.
- None of the side branches we checked along the lower 1.3 miles of the main storm drain in Diagonal Ave. S showed any evidence of oil.

City of Seattle

Norman B. Rice, Mayor

Seattle Public Utilities
Diana Gale, Director

MEMORANDUM

DATE: February 6, 1997

TO: Cheryl Paston, WQ Unit, SPU - Water Resources Planning

FROM: Tai Ovbiebo/Nian She, SPU - Water Resources Planning

SUBJECT: Diagonal Avenue Outfall Quality Modeling & Analysis Report Summary.

INTRODUCTION

Elliott Bay and the Duwamish River receive stormwater runoff from approximately twenty-four square miles of highly developed land in metropolitan Seattle. Industrial, commercial and residential stormwater runoff, illegal discharges, illicit connections to storm drains, and oil and chemical spills have been identified as significant contributors to the degradation of water quality in Elliott Bay and the Duwamish Waterway. Tidal influence can extend upstream in the storm drains for over a mile during a moderate tide. Since most areas in the drainage basin are below or near the sea level elevation, the outfall is only accessible during the ten or so lowest tides of the year. A successful stormwater sampling effort can occur only in storm conditions during low tide, which is approximately below -1.5 feet. This made it very difficult to obtain a valid number of stormwater samples to estimate pollutant loads in such a heavily commercial and industrialized area statistically without the use of mathematical models. The Principle Component method was also use to evaluate the sensitivity of the model. The basin was divided into nineteen subcatchments of sizes ranging from 11 acres to 155 acres. Major drainage conduits diameters ranged from 12 inches to 144 inches. Stormwater samples were collected at the site downstream of the gauging station. Precipitation data were collected at rain gauge stations in the basin.

PROJECT OBJECTIVES

The following objectives were established for this study:

- Monitor the quantity of stormwater that is discharged from typical subcatchments.
- Use information from monitoring and sampling of stormwater flow at strategic locations in the watershed to model the runoff from all subcatchments served by separate stormwater sewers that discharge into the Duwamish River.
- Estimate the annual pollutant loading to the Duwamish River from the watershed.

FUNCTIONS OF THE WATER QUALITY MODEL (XP-SWMM)

The following are the functions of this water quality model:

- To evaluate current and future conditions of a water body as a result of pollutant discharge and to evaluate the relative magnitude of the pollutants;
- To evaluate the relative contributions from different land uses in order to target management plans;
- To rank the subcatchments based on relative stormwater pollutant loading to the river.
- To aid in design and evaluation of mitigation measures, including Best Management Practices (BMPs) ;
- To monitor improvements in surface water quality.

APPROACH TO STORMWATER MODELING

In order to estimate the flow and pollutant loading discharged to the river from the outfall, a computer model was used to simulate the stormwater runoff. Continuous simulations were performed for the actual storm events, using the 1980 rainfall data. Single event storms were also used for calibration of the model. The steps taken in developing a system representation of the drainage basin for the computer model include delineation of the drainage boundaries based on the topography of the areas. The basin was divided into 19 subcatchments of sizes ranging from 11 acres to 155 acres. Major drainage conduits (pipes 12 inches or bigger) and maintenance holes were represented by numbered links and nodes. Flow monitor locations were identified at specific nodes. Following development of the system schematic, input parameters representing the physical characteristics of the subcatchments, conduits and maintenance holes were compiled.

MODEL INPUT PARAMETERS

Precipitation Data

The review of Seattle rainfall data revealed that rainfall distribution in the area is highly variable, both temporally and spatially. To successfully calibrate the model, rainfall data in 10-minute intervals from the City rain gauge station number 15 was used for the calibration runs. These stations are close to the flow monitoring stations and were considered representative of the actual rainfall that occurred during a monitored event.

Two types of precipitation data were used for the modeling efforts:

- Data from rain gage station 15 for the storms of December 26-28, 1994, which we estimated to have a 2-year return period was used to estimate the volumes of stormwater runoff.
- Data from rain gauge station 15 for the storms of 1980, which we estimated to be more representative of the rainfall pattern in the Seattle area having a total accumulation of 34.76 inches was used for continuous simulation.

Evaporation Data

In XP-SWMM, evaporation data are important for model simulation of continuous time periods in order to represent the emptying of depression storage during dry periods between storms. Evaporation is subtracted from rainfall depths prior to calculating infiltration.

Subcatchment Data

Data on subbasin characteristics required for the model include area, width, slope, percent of impervious area, roughness coefficients, depression storage, and infiltration rates. These parameters were also the most sensitive during calibration.

Conduit Data

Physical data required for conduits represented in the model included length, diameter, slope, and hydraulic roughness. Data from the Puget Sound Tide tables were used to simulate the tidal influence at the outfall.

Model Calibration and Sensitivity Analysis.

In order to simulate and calibrate the pollutant loading from the stormwater runoff, five samples were collected near the end of the outfall. One sample was collected during a period of dry conditions to represent "baseline" condition, and four other samples were collected during storm events. Two of the four samples were collected during the "wet" season (November through April) and another two were collected during the "dry" season (May through October). These samples were used to calibrate the simulation results.

Mean Pollutant Concentration

Mean pollutant concentrations were estimated for the Diagonal Avenue storm drain system. Stormwater samples taken from the existing storm drain systems were analyzed for detectable pollutant concentrations. The mean concentration of pollutants in each storm drain sampling station was estimated by taking the unweighted arithmetic averages of the sampling data. When necessary NURP data was substituted for missing data and no attempts were made to re-calculate the coefficient of variation for each pollutant.

Mean Pollutant Loading

Mean annual pollutant loading were calculated by the model in conjunction with present and actual rainfall from the 1980 rainfall data which we picked to be more representative of the rainfall pattern in the basin to simulate the hydrologic cycle and estimate the total runoff for the Diagonal Avenue outfall. This station records slightly higher volumes than the rest of the gauges in the City.

ESTIMATES OF ANNUAL LOADING

Methodology

To estimate loading from each of the delineated basin, the average concentration were multiplied by the flows generated by the computer model. The total loading computed include those pollutants associated with solids in the stormwater samples which were represented as "potency factors" in the model. These loadings were then divided by the tributary area upstream of the monitoring station to get average loading per acre per year.

For comparison a mass loading of pollutants to the Duwamish River were also estimated using the runoff volumes generated by the model and the average concentration of pollutants in stormwater samples obtained from the study by using the rating curve approach as described below.

Rating Curves

The term rating curve is a special form of regression analysis, in which concentration and/or loads are related to flow rates and/ or volumes (Huber, 1992). Subcatchment load rates are computed at each time step per the following equation:

$$POFF = RCOEF \times WFLOW^{WASHPO}$$

where:	WFLOW	= subcatcment runoff, cfs
	POFF	= constituent load washed off at time, t, mg/sec
	RCOEF	= coefficient that includes correct unit conversion
	WASHPO	= exponent

ASSUMPTIONS:

- The average pollutant concentration represents the maximum average since first flush and typical storm events were used to develop the average.
- All conduits represented in the model were circular, reinforced concrete pipes.

- A mannings "n" value of 0.013 was assumed as the initial roughness coefficient for all conduits.
- The rainfall data used is assumed to be representative of entire basin.
- Land use was mostly Industrial.
- Event mean concentrations are lognormally distributed across the site.

MODEL RESULTS

For this study, checks were made with the historical data used on other projects using the same watershed characteristics, pollutant concentrations and storm data from the same rain gauge station. Runoff from a large storm event occurring after a long dry period would most likely contribute greater loading, due to the accumulation of sediments and other pollutants prior to the storm. Predicted loads were compared to the results obtained from these studies and where necessary, corrections were made to the model. Detailed sensitivity analysis was performed using the statistical Principle Component method to analyze uncertainty in the loading results and to increase the confidence bounds. The output from this analysis compared favorably to other highly developed urban areas similar to the City of Seattle and a linear regression performed also show an R-squared value of 0.96

SUMMARY

In summary metal concentrations from Diagonal Avenue storm drain outfall were generally at the same level as selected saltwater or freshwater criteria at most locations. However, the total Zinc, Lead and Copper concentrations were slightly higher than those reported for other locations. Although it would be expected that industrial land use would account for very high pollutant concentrations, initial test results did not indicate this was the case. In general, this may be due in part to land use from high density low income areas of the basin tending to generate higher level of pollutant concentrations plus the weather pattern in the Seattle area which is sometimes light winter rainfall. This light and consistent rainfall may account for low pollutant concentrations because consistently low rates of runoff wash the pollutants into the storm drain system, thus preventing accumulation that could cause large pollutant concentrations. The pollutant concentrations were very similar for the typical storms between subcatchments with only slight variation in the physical characteristics.

Estimates of the pollutant loading of cummulative discharges from Outfall 591 to Duwamish River for a total rainfall accumulation of 34.76 inches at SED station #14.

Sub Basin #	Land Use	Trib Area (acre)	% Imp Surf	Runoff Coeff	Mean Annual Rainfall (in)	Mean Annual Discharge (cf)	Mean Annual Discharge (acre-ft)	Unit Conver. Factor ac-ft, ug/l => lbs	AS c=2.75ug/l Mean Annual Loading (lbs/yr)	CR c=7.3ug/l Mean Annual Loading (lbs/yr)	CADMIUM c=.55ug/l Mean Annual Loading (lbs/yr)	SILVER c=0.0ug/l Mean Annual Loading (lbs/yr)	NICKEL c=11.18ug/l Mean Annual Loading (lbs/yr)	MECURY c=.12ug/l Mean Annual Loading (lbs/yr)	BUTYL c=.59 ug/l Mean Annual Loading (lbs/yr)	BIS(2-ethyl) c=7.15 ug/l Mean Annual Loading (lbs/yr)	ZINC c=145.19ug/l Mean Annual Loading (lbs/yr)	COPPER c=47.0ug/l Mean Annual Loading (lbs/yr)	LEAD c=39.29ug/l Mean Annual Loading (lbs/yr)
5	I	63.6	86	0.80	34.76	6.44E+06	147.77	0.00272	1.11E+00	2.93E+00	2.21E-01	0.00E+00	4.49E+00	4.82E-02	2.37E-01	2.15E-02	5.84E+01	1.89E+01	1.58E+01
10	I	42.1	58	0.61	34.76	3.22E+06	73.91	0.00272	5.53E-01	1.47E+00	1.11E-01	0.00E+00	2.25E+00	2.41E-02	1.19E-01	1.08E-02	2.92E+01	9.45E+00	7.90E+00
15	I	72.7	78	0.75	34.76	6.84E+06	157.12	0.00272	1.18E+00	3.12E+00	2.35E-01	0.00E+00	4.78E+00	5.13E-02	2.52E-01	2.29E-02	6.20E+01	2.01E+01	1.68E+01
20	I	155.1	40	0.48	34.76	9.39E+06	215.68	0.00272	1.61E+00	4.28E+00	3.23E-01	0.00E+00	6.56E+00	7.04E-02	3.46E-01	3.14E-02	8.52E+01	2.76E+01	2.30E+01
25	I	38.2	30	0.41	34.76	1.98E+06	45.37	0.00272	3.39E-01	9.01E-01	6.79E-02	0.00E+00	1.38E+00	1.48E-02	7.28E-02	6.60E-03	1.79E+01	5.80E+00	4.85E+00
30	I	111.6	33	0.43	34.76	6.07E+06	139.35	0.00272	1.04E+00	2.77E+00	2.08E-01	0.00E+00	4.24E+00	4.55E-02	2.24E-01	2.03E-02	5.50E+01	1.78E+01	1.49E+01
35	I	120.2	26	0.38	34.76	5.79E+06	133.02	0.00272	9.95E-01	2.64E+00	1.99E-01	0.00E+00	4.05E+00	4.34E-02	2.13E-01	1.94E-02	5.25E+01	1.70E+01	1.42E+01
40	I	47.3	32	0.42	34.76	2.53E+06	58.10	0.00272	4.35E-01	1.15E+00	8.69E-02	0.00E+00	1.77E+00	1.90E-02	9.32E-02	8.45E-03	2.29E+01	7.43E+00	6.21E+00
45	I	50.8	24	0.37	34.76	2.36E+06	54.16	0.00272	4.05E-01	1.08E+00	8.10E-02	0.00E+00	1.65E+00	1.77E-02	8.69E-02	7.88E-03	2.14E+01	6.92E+00	5.79E+00
50	I	70.7	79	0.75	34.76	6.72E+06	154.23	0.00272	1.15E+00	3.06E+00	2.31E-01	0.00E+00	4.69E+00	5.03E-02	2.48E-01	2.24E-02	6.09E+01	1.97E+01	1.65E+01
55	I	72.5	85	0.80	34.76	7.27E+06	166.98	0.00272	1.25E+00	3.32E+00	2.50E-01	0.00E+00	5.08E+00	5.45E-02	2.68E-01	2.43E-02	6.59E+01	2.13E+01	1.78E+01
60	I	79.4	90	0.83	34.76	8.32E+06	190.92	0.00272	1.43E+00	3.79E+00	2.86E-01	0.00E+00	5.81E+00	6.23E-02	3.06E-01	2.78E-02	7.54E+01	2.44E+01	2.04E+01
65	I	72.2	90	0.83	34.76	7.56E+06	173.61	0.00272	1.30E+00	3.45E+00	2.60E-01	0.00E+00	5.28E+00	5.67E-02	2.79E-01	2.53E-02	6.86E+01	2.22E+01	1.86E+01
70	I	74.3	90	0.83	34.76	7.78E+06	178.66	0.00272	1.34E+00	3.55E+00	2.67E-01	0.00E+00	5.43E+00	5.83E-02	2.87E-01	2.60E-02	7.06E+01	2.28E+01	1.91E+01
75	I	61.9	26	0.38	34.76	2.98E+06	68.50	0.00272	5.12E-01	1.36E+00	1.02E-01	0.00E+00	2.08E+00	2.24E-02	1.10E-01	9.97E-03	2.71E+01	8.76E+00	7.32E+00
80	I	27.9	25	0.38	34.76	1.32E+06	30.31	0.00272	2.27E-01	6.02E-01	4.53E-02	0.00E+00	9.22E-01	9.89E-03	4.86E-02	4.41E-03	1.20E+01	3.87E+00	3.24E+00
85	I	20.6	38	0.47	34.76	1.21E+06	27.81	0.00272	2.08E-01	5.52E-01	4.16E-02	0.00E+00	8.46E-01	9.08E-03	4.46E-02	4.05E-03	1.10E+01	3.56E+00	2.97E+00
90	I	71.1	14	0.30	34.76	2.67E+06	61.38	0.00272	4.59E-01	1.22E+00	9.18E-02	0.00E+00	1.87E+00	2.00E-02	9.85E-02	8.93E-03	2.42E+01	7.85E+00	6.56E+00
95	I	29.6	14	0.30	34.76	1.11E+06	25.55	0.00272	1.91E-01	5.07E-01	3.82E-02	0.00E+00	7.77E-01	8.34E-03	4.10E-02	3.72E-03	1.01E+01	3.27E+00	2.73E+00
TOTAL		1281.8	50	0.55	34.76	9.16E+07	2102.5	0.00272	1.57E+01	4.17E+01	3.15E+00	0.00E+00	6.39E+01	6.86E-01	3.37E+00	3.06E-01	8.30E+02	2.69E+02	2.25E+02

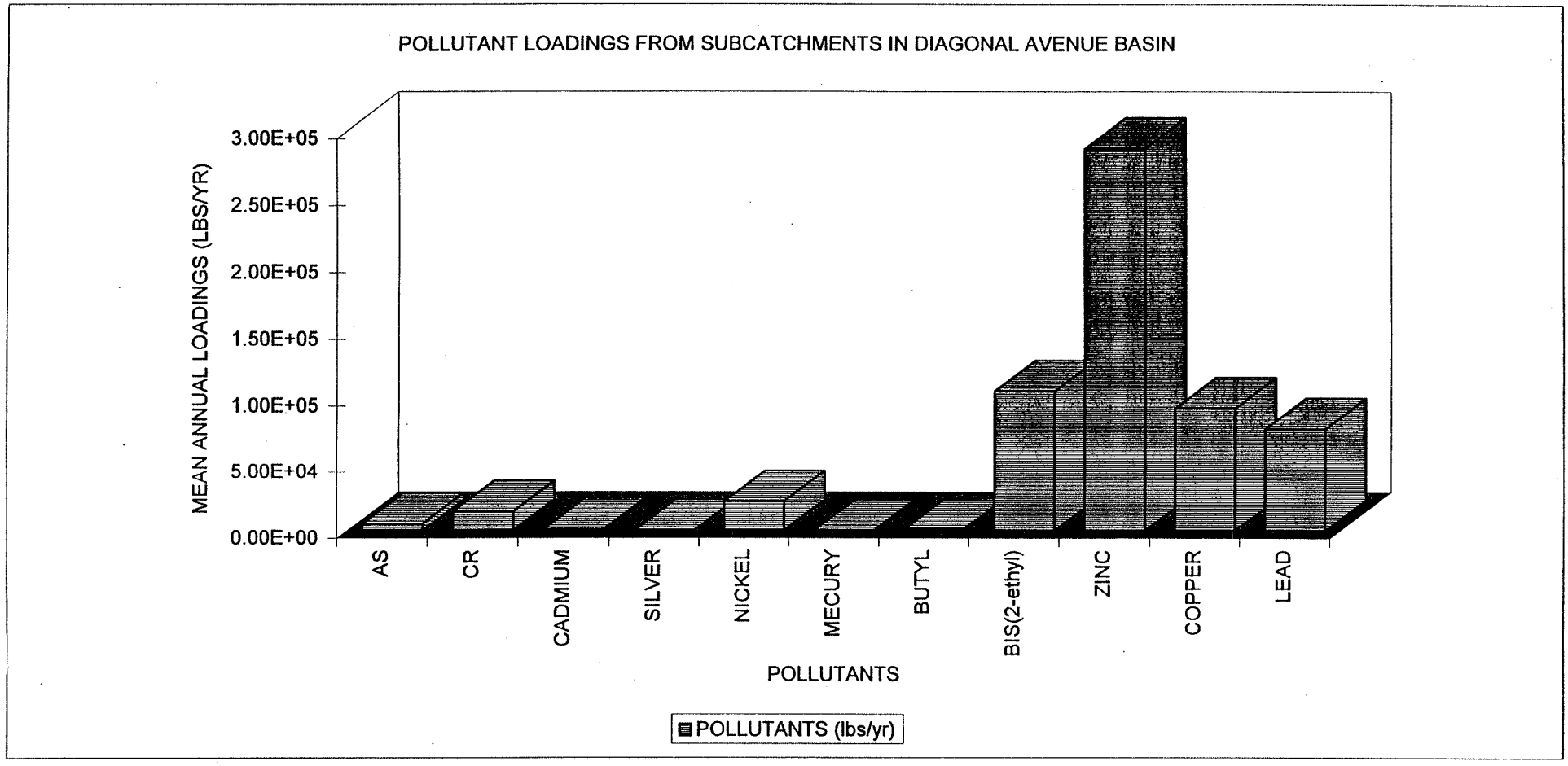

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Figure 1.

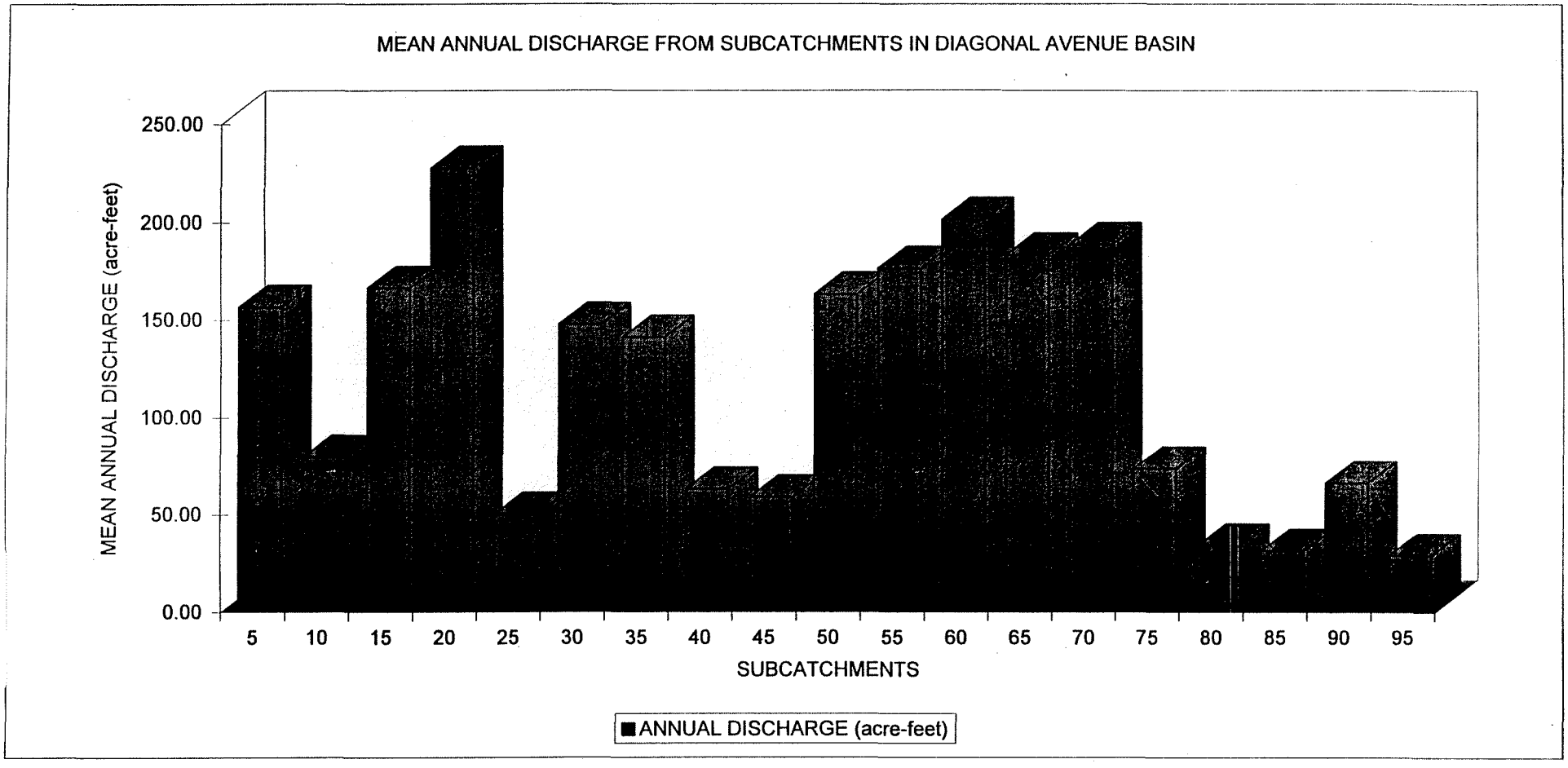

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Figure 2.

CITY OF SEATTLE

DIAGONAL AVENUE DRAINAGE BASIN

LEGEND

- Diagonal Basin
- Diagonal Sub-basins
- Sampling Stations
- Rain Guage
- Storm Mainlines
- City Outline
- Streets

Produced by Seattle Engineering Department's Drainage and Wastewater Utility, March 24 1995

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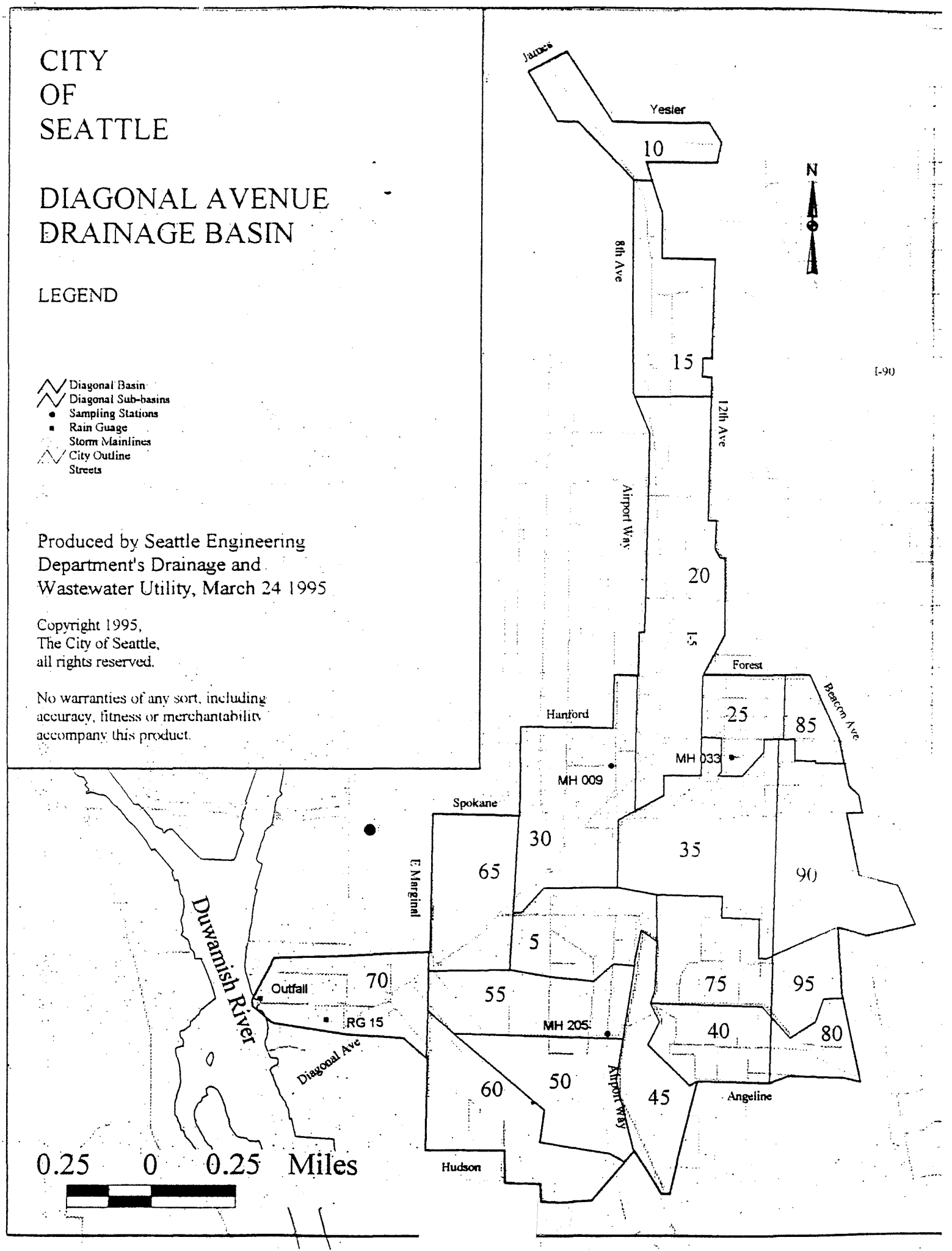
No warranties of any sort, including accuracy, fitness or merchantability accompany this product.



Solving a Century-old Problem

The City of Seattle and Metro are working to reduce combined sewer overflows (CSOs), the periodic discharge of untreated sewage and stormwater runoff into the Duwamish River and other surface waters. CSOs are a legacy from an earlier era.

At the turn of the century, the newly chartered City of Seattle grappled with the question of how to manage its sewage. A consulting engineer convinced the City to build a combined system that carried both sewage and stormwater runoff. His report explained that removing stormwater "is a necessity in a modern city" and that "if sewage and stormwater are not removed together...underground conduits will have to be [separately] provided for rain water...materially increasing the cost."

Building combined systems remained the standard engineering practice in Seattle until the early 1940s. These systems were designed to overflow into the Duwamish River and other waters when rains taxed the system's capacity.

Current Washington State requirements mandate that combined sewer overflows be controlled to an average of not more than one discharge per year from each overflow point. Metro, which typically owns the largest pipes, and therefore the largest CSOs, negotiated an interim goal. Metro's goal is to reduce the volume of its CSO discharges by 75% system-wide by the year 2005.

In the Duwamish watershed, the City of Seattle has achieved the required level of CSO control, and Metro has begun its control work. Three of the strategies available to manage CSOs are:

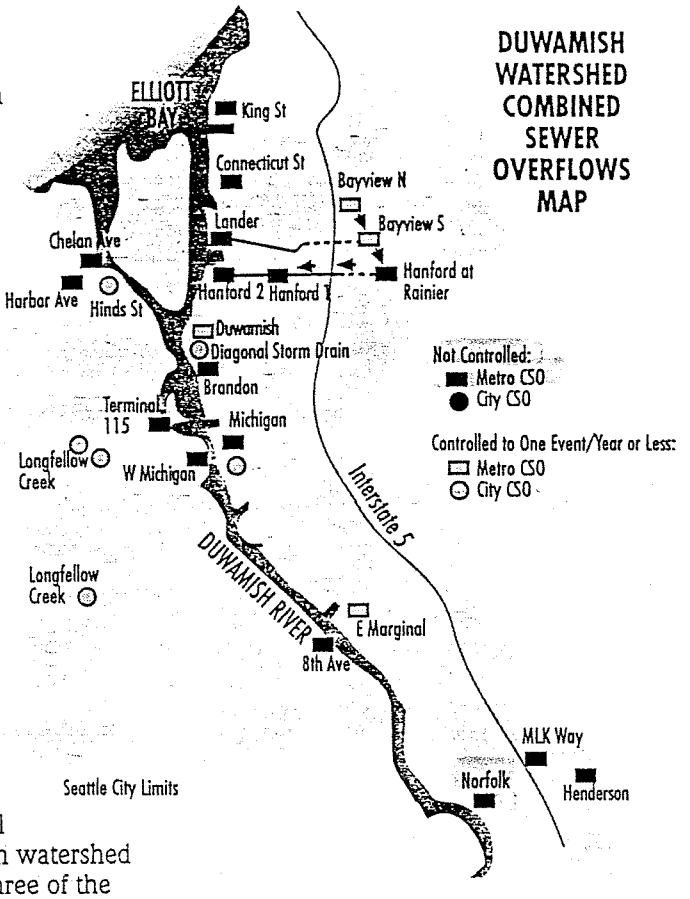
- storage—installing a tank or large pipe to store peak flows until they can be conveyed to a sewage treatment plant;
- separation—reducing the amount of water that enters the combined sewer by installing separate pipes to carry some or all of the stormwater runoff directly to a water body; and
- treatment—building facilities to treat peak flows and then discharge them to a nearby water body.

The City used the first two strategies, sometimes in combination, to control its CSOs (see map). For example, the Diagonal Ave. South CSO control project included storage as well as new storm drainage pipes. As a result of that project, most stormwater runoff from businesses in the affected area south of Spokane St. now goes to the Duwamish River rather than a treatment plant.

Metro's completed and planned CSO control projects in the Duwamish watershed collectively will use all three of the listed control strategies — storage, separation, and treatment. For example, the tunnel that Metro is building to divert Alki sewage flows to the West Point Treatment Plant will also provide storage to reduce Metro's Harbor Avenue CSO.

Metro is still evaluating how to control some of its Duwamish River CSOs. Long-term CSO control options are being examined as part of Metro's Regional Wastewater Services Plan. To learn more about that plan, contact Anne Greenwald, 684-1156.

Meanwhile, you can **call the Seattle Street Use Counter, 684-5283, to find out whether runoff from your property drains to the storm drainage system or a combined sewer.** Only clean stormwater runoff should enter the storm drainage system, and many substances are limited or prohibited from entering a combined sewer. Call Metro at 689-3000 to find out more about combined sewer regulations.

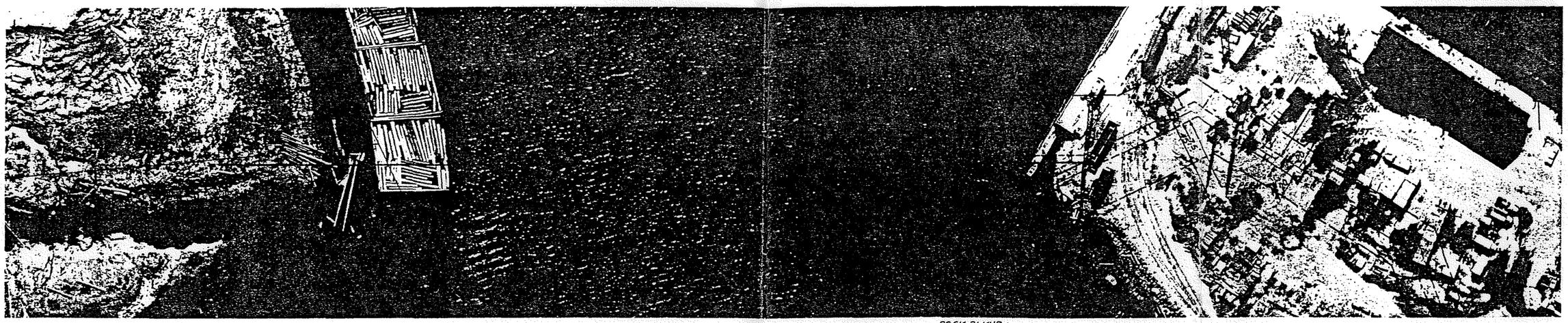


Upcoming Events

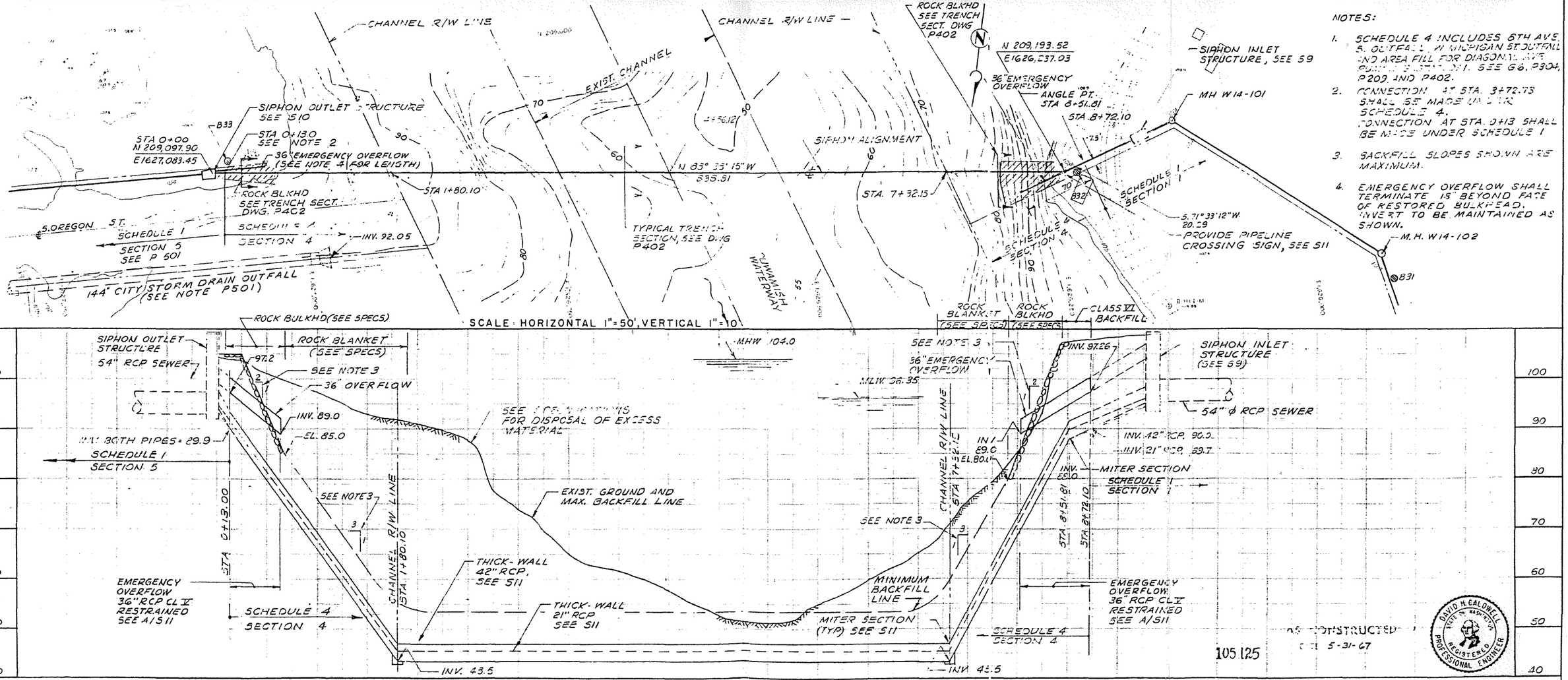
October 14, 10 am to 5 pm
Festival of the Rivers, celebration and stewardship of the Green and Duwamish Rivers. The festival offers workshops and entertainment at Van Doren's Landing Park in Kent and at two hub sites, including one at the Boeing Oxbow parking lot, just off West Marginal Way S. Other activities such as tree plantings, stream clean-ups, and tours of model businesses will occur throughout the watershed. For more information, call Jo Goeldner at 296-8361, or Steve Taylor, 296-8018.

October 17-18
Waste Information Network (WIN) Expo at the Seattle Center Exhibition Hall. Call 467-9682 for information.

Appendix E
Duwamish/Diagonal Outfall Details



PHOTOGRAPHY PERFORMED IN MARCH 1964



NOTES:

1. SCHEDULE 4 INCLUDES 6TH AVE. S. OUTFALL, W. MICHIGAN ST. OUTFALL AND AREA FILL FOR DIAGONAL AVE. BURLINGTON NT. SEE G6, P304, P209 AND P402.
2. CONNECTION AT STA. 3+72.73 SHALL BE MADE UNDER SCHEDULE 4. CONNECTION AT STA. 0+13 SHALL BE MADE UNDER SCHEDULE 1
3. BACKFILL SLOPES SHOWN ARE MAXIMUM.
4. EMERGENCY OVERFLOW SHALL TERMINATE 15' BEYOND FACE OF RESTORED BULKHEAD. INVERT TO BE MAINTAINED AS SHOWN.

LM / HC / LM	METROPOLITAN ENGINEERS	MUNICIPALITY OF METROPOLITAN SEATTLE					FILE W 214 C / DATE JUNE 1965	WEST POINT SYSTEM	WEST DUWAMISH INTERCEPTOR - SECTION 4 SEWER SIPHON STA. 0+13 TO STA. 8+72.73 EMERGENCY OVERFLOW	DRAWING NUMBER P 401 B-3
		SUBMITTED	DESIGNED	APPROVED	APPROVED	APPROVED	SCALE AS NOTED			

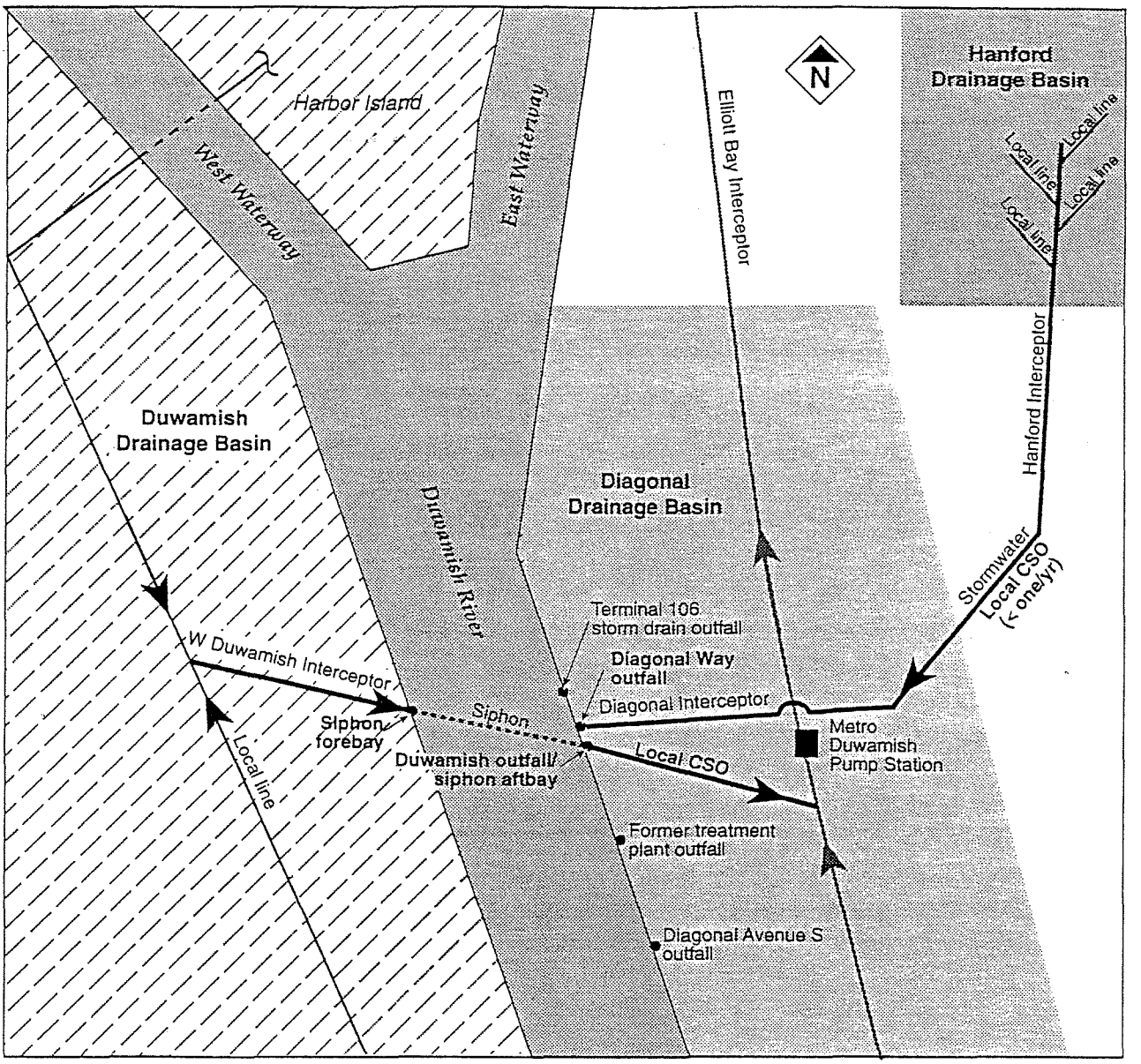
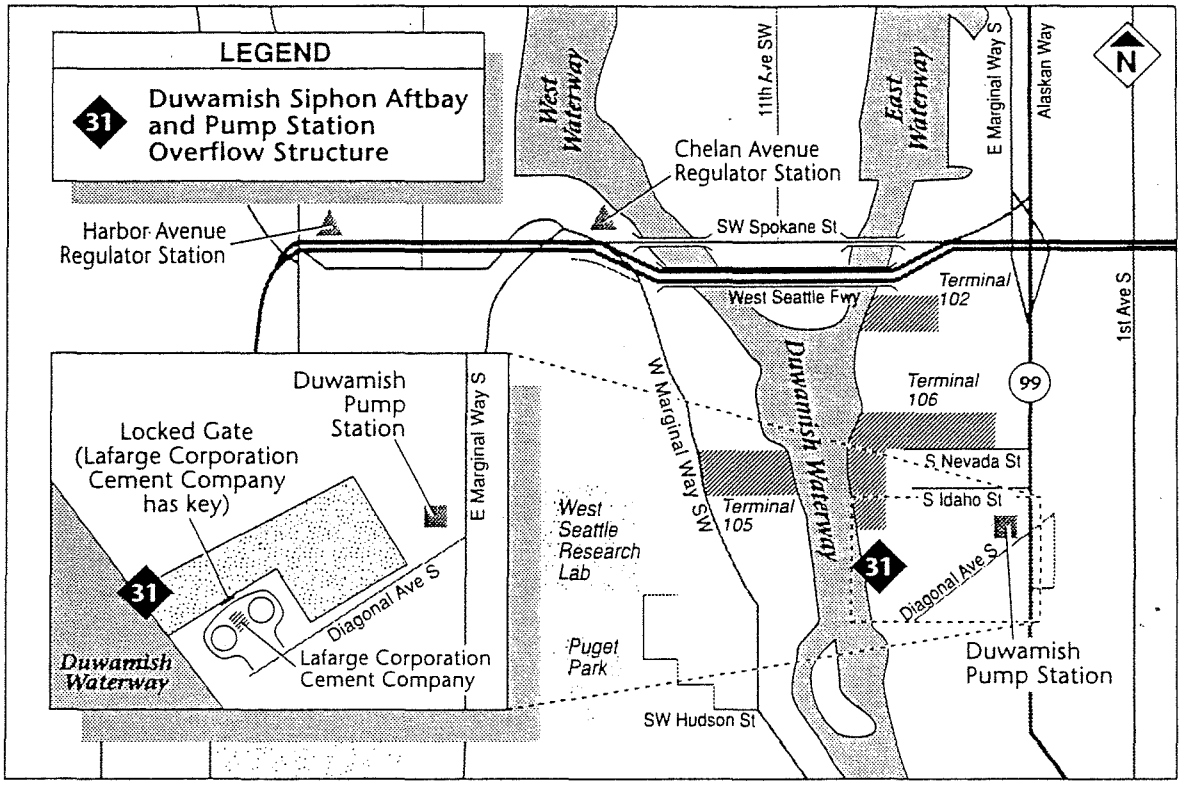


Figure 3-1. Generalized Duwamish/Diagonal CSO Schematic

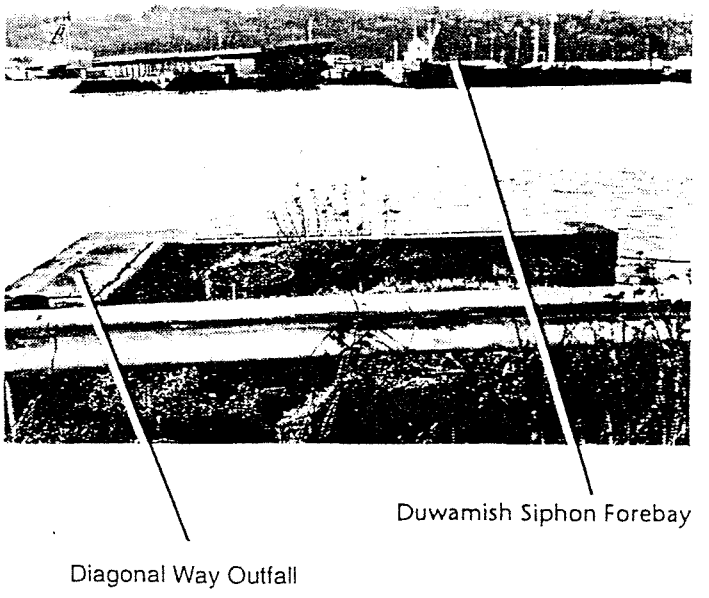
DUWAMISH SIPHON AFTBAY AND DUWAMISH PUMP STATION OVERFLOW STRUCTURE

4601 Diagonal Avenue S, Seattle

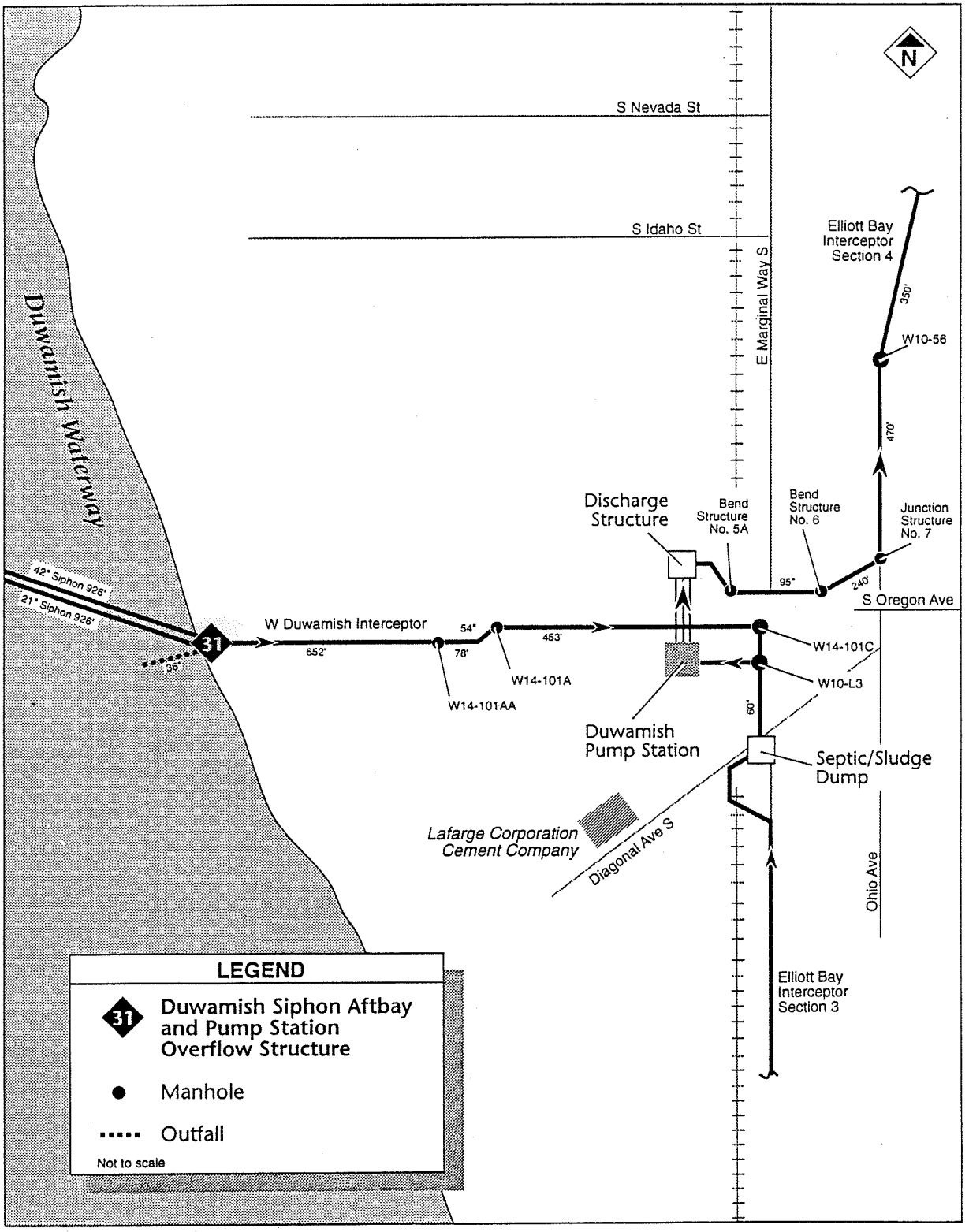


Directions

Siphon Aftbay . The siphon aftbay is located at 4601 Diagonal Avenue S in a field adjacent to the Lafarge Corporation Cement Company, at the east edge of the Duwamish River Waterway and on the south side of a large signpost. Access to this site is through the Lafarge Corporation gate (on Diagonal Way S).



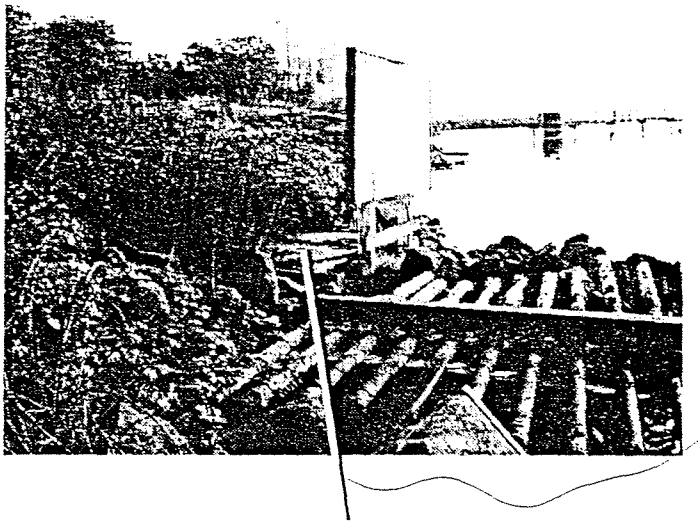
Source: Adapted from Metro, 1993a.



Source: Adapted from Metro, 1993a.

Duwamish One-Line Drawing

Duwamish Pump Station Aftbay and Overflow Structure. The overflow structure is located at 4601 Diagonal Avenue S in a field adjacent to the Lafarge Corporation Cement Company, at the east edge of the Duwamish River Waterway and on the south side of a large signpost. Access to this site is through the Lafarge Corporation gate (on DiagonalWay S).



Duwamish Siphon Aftbay (outfall pipe is in river below low tide level).

Structure Access Peculiarities

NOTE

The combination to the Lafarge Corporation Cement Company pad-locked gate is 6002.

The two sites are on the east bank of the West Duwamish Waterway, directly in front of the unpaved, unkept driveway that comes in from East Marginal Way South almost to the water's edge.

To get to the overflow structure, proceed south from the aftbay through the blackberry vines to the water's edge and the 4-foot by 3-foot sign.

System Relationship

The gated Duwamish Siphon aftbay directs flow to the Duwamish Pump Station and from there into Section 1 of the Elliott Bay Interceptor (EBI).

The Duwamish Pump Station Overflow Structure empties into the West Duwamish Waterway.

Structure Description

The aftbay is the manhole nearest the water. It includes a flap gate and an overflow with a two-barrel siphon. The Duwamish Pump Station Overflow Structure is also near this site, at the water's edge, just south of the Duwamish Siphon Aftbay under the large 4-foot by 3-foot sign.

The two-barrel siphon directs flow to the Duwamish Pump Station from the Duwamish Siphon Forebay, while the overflow structure protects the pump station from flooding.

Operator Services

WARNING
Always check the atmosphere in a confined space before entering. Wear safety equipment, as stipulated in the WPCD Safety Handbook, *and abide by all safety regulations for entering a confined space.*

- Lubricate the flap gate hinges, as needed.
- Observe the flow of wastewater through the line to verify that the siphon is not plugged.

Source: Adapted from Metro, 1993a.

Appendix F
Habitat Survey data

Duwamish/Diagonal & Norfolk Sediment Remediation Projects Project 12601

TEAM MEMORANDUM

DATE: NOVEMBER 18, 1995
TO:
TERI
FLOYD

TASK NO: 100
FROM: Jon Houghton, Pentec Environmental

SUBJECT:

October 19, 1995 Site visit to the Duwamish/Diagonal Outfalls

On October 19, 1995, I visited the site of the Duwamish and Diagonal outfalls with Allan Chartrans of EcoChem. We met at the parking lot of the Port of Seattle's Terminal 108 pocket beach mitigation project at about 0800. Low tide was xxft MLLW at 0745.

Habitat conditions observed

From the Port's mitigation area north (downstream) toward the site, the shoreline exhibited the following general habitat zonation:

The upper beach was relatively low gradient and thinly vegetated with riparian vegetation including dune grass, forbs, and willows. At the extreme high water line there was a debris line of woody and herbaceous material and miscellaneous human refuse. A narrow band of sand sloped gradually down to contact with a broad and relatively flat clay formation that extended out from under the sand layer down to a scarp of about 0.5 to 0.8 m in height where the clay had been eroded (or dredged?) by the river. Below this clay layer a gradually sloping sandy mud beach extended into the water.

The clay layer was densely perforated in some areas by decaying roots, possibly of a species of *Scirpus*. Large numbers of small white worms, probably oligochaetes, were present among the decaying roots within the clay. Other biota were sparse across this beach profile except for abundant barnacles (*Balanus glandula*) and some mussels (*Mytilus trossulus*) on occasional hard substrata on the beach.

This document is part of inter-team correspondence; it is not a reviewed work product.

Beginning at the southernmost leg of the "E" pier, the upper beach is protected by riprap which narrows the upper beach considerably. The clay layer continues past the first leg of the pier and past the location of the former city ~~treatment~~ plant outfall. From the center span from the pier northward, the clay layer is much diminished and the riprap extends lower into the intertidal zone. Below the riprap, the lower beach is sand with cobble and anthropogenic debris. Two seep areas cross the lower beach where iron-rich water flows out across the beach and forms deposits of iron oxides.

From the downstream end of the E pier downriver well past the Duwamish outfall, the entire visible intertidal area is riprapped except for a small pocket beach just north of the Diagonal outfall. At mid to lower intertidal elevations the riprap and pilings support a typical epibiota dominated by barnacles, mussels and rockweed (*Fucus gardneri*). Large numbers of mussels of reasonable size (30 to 50 mm) may comprise the most probable pathway for contaminant accumulation by a species that could be consumed by humans.

The pocket beach is a sandy gravel flat beginning at about +4 ft and extending below the waterline. The pocket beach appeared to have a good infauna with abundant polychaetes and oligochaetes. Shore crabs (*Hemigrapsus oregonensis*) were common under cobbles on the beach but no clams were found.

Habitat restoration opportunities

The intertidal zone, especially behind the E pier contains various types of anthropogenic debris that could be removed to return the beach to a more natural condition. Some of these materials, however, support a dense epibiota that would be lost with their removal, however. Addition of gravel substrate to the surface of the clay outcrop could increase the productivity of that portion of the intertidal zone.

A good opportunity for large-scale habitat enhancement may exist in the area just south (upstream) of the Duwamish outfall. The uplands behind (east) of the top of the riprapped shoreline is currently unused early successional scrub shrub. If this property were available, the shoreline could be cut back substantially adding habitat area in selected intertidal elevations. The middle and lower beach could be surfaced with a silty sand beach with the upper intertidal area planted with a fringe of saltmarsh vegetation. This area possibly could be connected with the trail leading downriver from the Port's Terminal 108 project area.

Duwamish/Diagonal & Norfolk Sediment Remediation Projects Project 12601

TEAM MEMORANDUM

DATE:	November 12, 1996	**TASK NO:**	213-004-11
TO:	Ms. Kathryn Carpenter, EcoChem Dr. Jonathan Houghton, Pentec	**FROM:**	Rob Gilmour, Pentec
SUBJECT:	Duwamish Diagonal Site Visit		

July 29, 1996 Site Visit to the Duwamish/Diagonal Outfalls

On July 29 I visited the site with Cliff Whitmus. We were met by three Metro employees at the parking lot of the Port of Seattle's Terminal 108 pocket beach at about 0815. Low tide was -2.4 ft (MLLW) at 1034.

Methods

Starting at the upstream end of the project area, we established transects downslope from the highwater mark to the water's edge. Substrate type, community dominants, and macroinfauna were recorded along the transects. Pertinent slope and bank height information was also recorded for each transect.

Conditions Observed

The first transect was established on the downstream side of the Diagonal Avenue South outfall. The highwater mark was at the remains of a timber bulkhead. The upper beach consisted of a band of fine sand approximately 28 ft wide. A series of clay benches with occasional patches of a thin sand overlay were found in the middle beach. A band of fine sand reappeared below the clay layer at 52 ft and continued down to the water's edge. Rubble at the end of the outfall supported growths of *Fucus* and *Enteromorpha*. Barnacles (*Balanus glandula*, mostly dead) were abundant on the hard substrata. Some *Porphyra* was also found attached to the rubble. Under the rubble were amphipods (*Eogammarus* sp.) and isopods (*Gnorimosphaeroma* sp.). Mussels (*Mytilus trossulus*) were found attached to the rubble.

A second transect was positioned downstream from the first transect to intersect an isolated clump of *Scirpus*; its root mat was located on the upper beach. The clay benches were prominent and had significant amounts of decaying root material associated with them. Scarps of up to 1 ft had been cut in the layers presumably by the current. No infauna was found, but holes presumably made by shorebirds probing the mud were seen on the surface. Below the clay benches in the sand band near the water's edge (near MLLW) were amphipods (*Corophium* sp.), molts of *Hemigrapsus oregonensis*, and small sculpins.

This document is part of inter-team correspondence; it is not a reviewed work product.

Pilings located near the transect supported a dense barnacle population, some mussels (mostly 1 cm or larger), and attached *Ulva*. No small mussels or spat were seen.

The third transect was established at the start of the riprap in the supralittoral and upstream of the chain-link fence. There was a narrow sand band below the toe of the riprap, then a band of mixed-sand and ballast rock. The clay bench continued with a thin overlay of sand before dropping 3 ft at a well-defined scarp to a band of fine sand with clay boulders that continued down to the water's edge. The layer of clay exposed by the scarp showed the upper 18 inches to be clay with abundant root material; the deeper layer was mostly clay with little plant material. Some polychaetes were found in the upper clay/root zone. The surface of the clay bench had *Ulva*, *Enteromorpha*, and benthic diatoms. Pilings and hard substrates in the vicinity were abundantly covered with barnacles, *Ulva*, *Enteromorpha*, and mussels. *Porphyra* was also occasionally found on the pilings.

The fourth transect was located just upstream of the small pocket beach located under the "E" pier. The upper band from the highwater mark to the clay outcrop was mixed sand and ballast rock. The sediment composing the clay bench at this transect appeared to have less plant material than the outcrops farther upstream. The surface of the bench was covered with benthic diatoms, and there was evidence of birds probing the surface but no infauna was evident. The eroding edge of the clay bench dropped 4 ft down to a narrow band of sandy clay. An oil sheen was seen at the water's edge at 0925 (-1.5 ft MLLW).

The fifth transect was located in the small pocket beach under the middle arm of the "E" pier. The prominent clay bench found upstream of this transect ended between Transects 4 and 5. The slope was covered with ballast rock for the upper 38 ft of the transect. Cobble-size chunks of clay were found on the surface with the ballast rock in the lower half of the ballast rock zone. A thin band of fine sand was found extending from the ballast rock zone to the water's edge. Abundant *Fucus* cover was found on the lower half of the ballast rock zone. An iron seep was seen at 23 ft and was apparently flowing from the top of the clay layer. Pilings and other hard substrata were covered with barnacles, mussels, *Ulva*, *Enteromorpha*, and *Porphyra*. No mussel spat were seen. An oil sheen was seen at the water's edge.

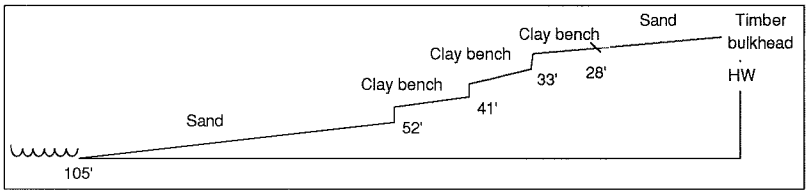
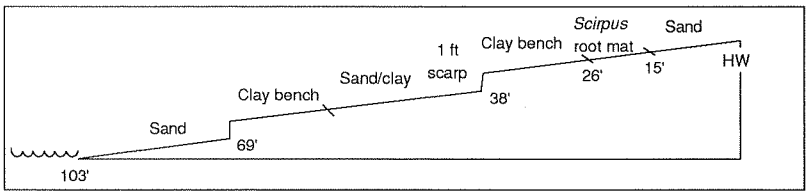
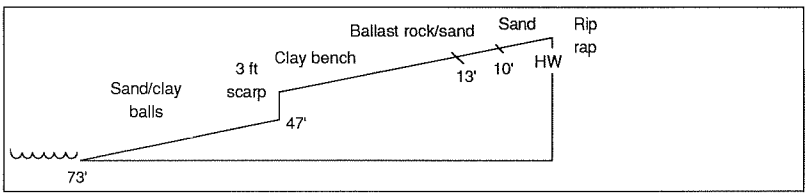
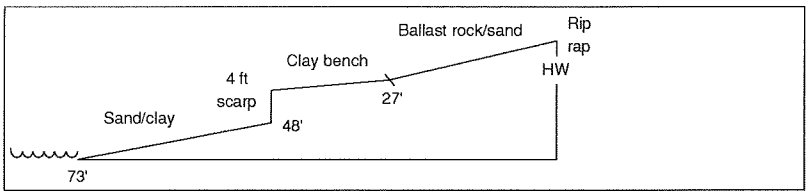
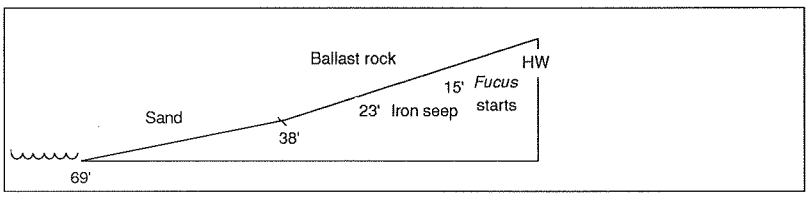
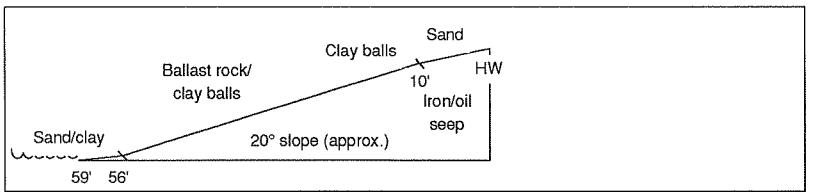
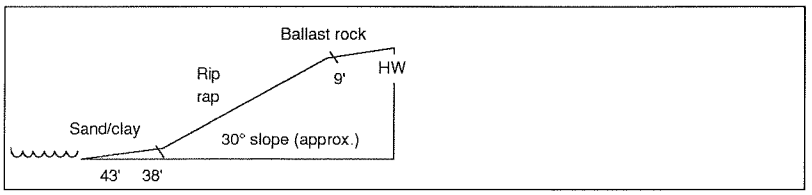
Transect 6 had a slope of 20° from the highwater mark to the water's edge. The upper beach had a narrow (10 ft wide) band of fine sand. A band of clay balls was present below this zone and appeared to represent a continuation of the clay layer that was prominent upstream of Transect 4. The cobble-size clay balls were mixed in with ballast rock in the middle portion of the beach. Several oil and iron seeps were found along the top of this layer. A band of green moss was found at the top edge of this zone. Ballast rock continued down to just above the water line where a thin band of sand was exposed by the tide. Hard substrata were covered by *Fucus*, *Ulva*, and *Enteromorpha*. Barnacle

cover was high but some mussels were also found. Some filamentous red algae were found in the lower intertidal. *Hemigrapsus* was common under rocks in the mid- to lower elevations.

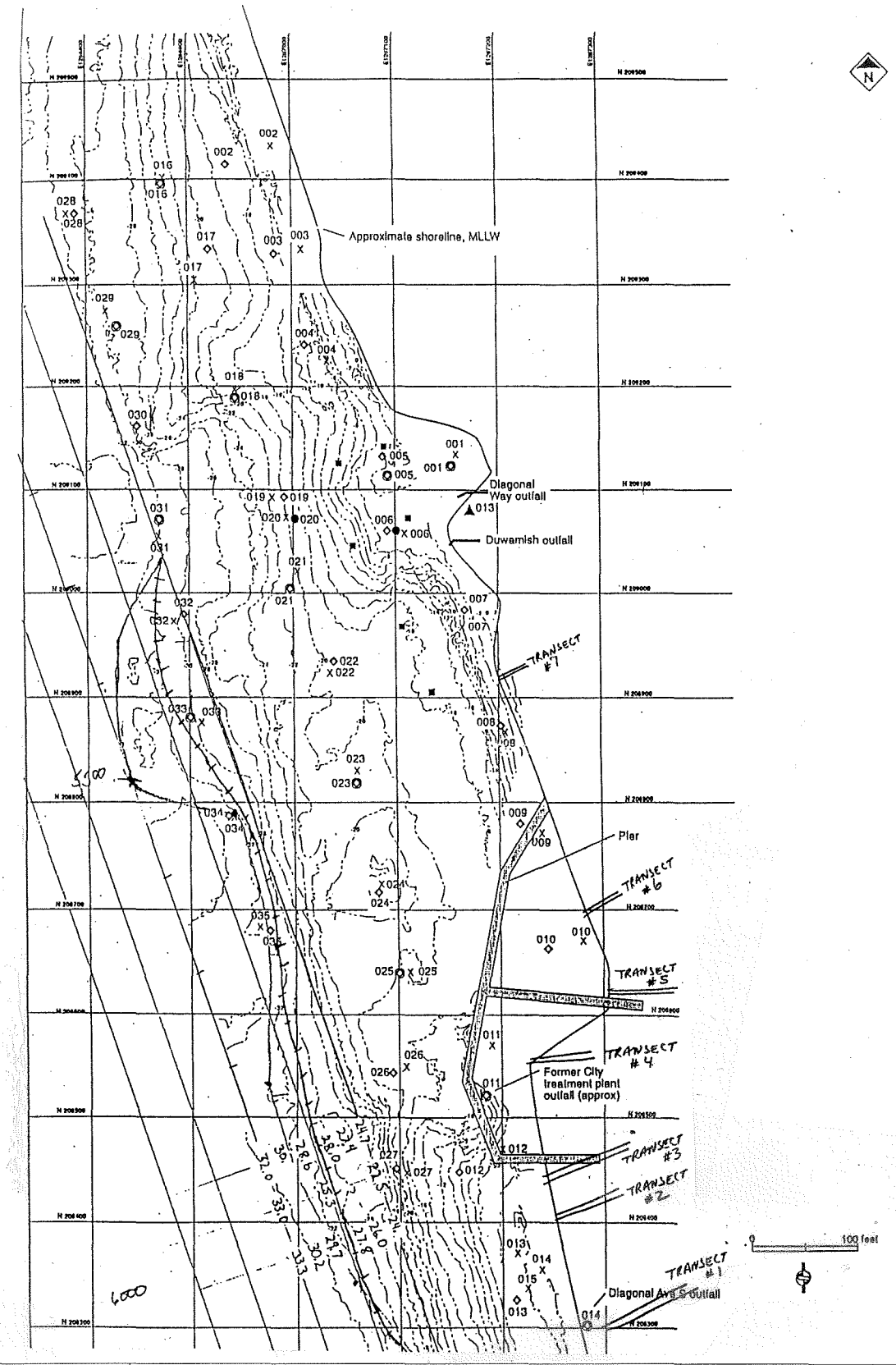
Transect 7 was located halfway between the downstream leg of the "E" pier and the Duwamish/Diagonal outfall. From the highwater mark out to 9 ft on the transect, the substratum was ballast rock. The major portion of the slope was armored with riprap at a slope of 30°. A band of sand and clay was exposed at the water's edge below the toe of the riprap. The location of the clay layer found upstream was indistinct under the ballast rock and riprap. The location of iron seeps may help to define the location of the top of the clay layer. Algal and animal communities were similar to the other hard substrata found within the study area.

The substrata and communities found in the area just upstream of the combined Duwamish/Diagonal outfalls were similar to the communities found at Transect 7. The slope appeared steeper (35°) and was armored with larger riprap. A typical hard substratum community was well-established on the rocks. The area directly in front of the outfalls consisted of a very soft, flocculent mud bank. The surface was too soft to walk on, and a strong hydrogen sulfide/hydrocarbon odor was present. The sediment appeared anoxic with hydrocarbon seeps present on the surface. No evidence of an infauna community was seen but close examination of the surface was avoided due to health and hygiene concerns. The sediments inside the small pocket beach area were more stable and appeared to have some burrows and other evidence of an infauna community. The beach slope downstream of the little pocket beach consisted of a heavily armored riprap slope of 45° with a similar *Fucus* dominated community.

Appendix Figure 2 Beach profiles at Duwamish Diagonal site. Horizontal and vertical distances are not to scale.

Transect	Upstream (S)	Notes
#1		Fucus and Enteromorpha on rubble at end of outfall. B. glandula (mostly dead) on hard substrates, some mussels. Other algae (Porphyra, Ulva). Amphipods (Eogammarus) and isopods under rubble.
#2		Clay banks with peaty eroding root mass. Scattered Enteromorpha. Evidence of shorebirds feeding (probe holes). Lower intertidal near water's edge-Amphipod Corophium and molts of Hemigrapsus.
#3		Start of riprap. Clay bank-top 18 in. root mass with little clay, below mostly clay. Some polychaetes present in clay and roots. Some Enteromorpha, Ulva and diatoms on surface of the mud.
#4		Clay bench has little plant material. Surface covered with diatoms. Some evidence of shorebird feeding. Oil sheen seen at waters edge.
#5		On pilings- abundant barnacles, some Ulva, Porphyra. Mussels present but no spat seen. Oil sheen seen at waters edge. Iron seeps with oil sheen emerging from top of clay layer. Scattered blocks of loose clay.
#6		Band of moss at edge of sand band in the upper intertidal @10 ft from highwater line. Fucus and Enteromorpha on ballast rock. Animals present include Hemigrapsus, Balanus, mussels. Scattered clumps of filamentous red algae.
#7		Riprap overlays clay bench. Iron seeps emerge from on top of the clay layer. Extensive Fucus cover, some Enteromorpha, filamentous reds and Mastocarpus papillatus.

Downstream (N)



EcoChem Team

Duwamish Diagonal Sediment Cleanup Study

Habitat Transects

Figure E-1

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Appendix G
Bis(2-ethylhexyl)phthalate Source Control Report

SOURCE INVESTIGATION OF BIS (2-ETHYLHEXYL) PHTHALATE

This is a report of the King County Metro Industrial Waste section's investigation of the source(s) of the contaminate bis (2-ethylhexyl) phthalate or diethylhexyl phthalate (DEHP) found during the Duwamish/Diagonal cleanup study. The Duwamish/Diagonal cleanup study was undertaken to characterize the spatial extent and magnitude of sediment contamination resulting from the discharge of the Duwamish combined sewer overflow (CSO) and the Diagonal stormdrain outfall. The information from the cleanup study will be used to remediate the marine sediments at the mouth of the Duwamish and Diagonal outfalls. An additional goal of this source investigation is to determine if additional source control targeted at DEHP is needed to ensure that a Duwamish/Diagonal cleanup would not be recontaminated.

SUMMARY OF SOURCE FINDINGS

The Duwamish/Diagonal cleanup study showed that DEHP concentrations were higher at Duwamish CSO and Diagonal stormwater outfall than anywhere else in the KC Metro service area. Generally high DEHP concentrations in the KC Metro service area can possibly be explained by detergents containing DEHP. Further study would be needed to more fully investigate this correlation. The higher sediment concentrations found at Duwamish/Diagonal are likely explained by illegal dumping of chemicals into the stormwater system.

Detergents

High phthalate concentrations were found in non-foaming detergents and are a likely contributor to high phthalate sediment concentrations in the KC Metro service area. Phthalates are added to laundry and other detergents as a de-foaming agent. Therefore, the less a detergent foams, the higher the phthalate content. High phthalate concentrations have been found in treatment plant influent and biosolids, and in marine sediments at CSOs. However, high DEHP concentrations in detergents do not completely explain why DEHP concentrations were higher in the Duwamish/Diagonal outfall sediments than other outfall sediments in the KC Metro service area.

Janco United

The potential major source of phthalates and other contaminants in the Duwamish/Diagonal outfall sediments appear to have originated from a janitorial chemical supply company that was formerly located on 4412 Fourth Avenue. Janco-United Incorporated formulated and repackaged a variety of commercial grade cleaners from concentrate. For approximately every working day for 27 months, concentration of chemicals ranging from dilute rinsate to discontinued concentrated product were discharged

by company employees down a storm drain that was illegally connected to the Diagonal stormdrain system.

While it appears that Janco-United's action is the primary cause for the DEHP contamination in the marine sediments at the Duwamish/Diagonal outfalls, many other factors could have a cumulative effect. DEHP's primary use is as a plasticizer in common plastics. Since DEHP is so common throughout the environment, "source control" efforts may be difficult or impossible.

DUWAMISH/DIAGONAL CLEANUP STUDY

The Duwamish and Diagonal outfalls are located in the lower portion of the Duwamish Waterway at approximately river km 3 in the south industrial section of Seattle. The cleanup study sampling area extended downstream from the outfalls approximately 110 m (360 ft), upstream approximately 250 m (820 ft) and offshore approximately 90 m (295 ft) (Figure 1). During the first phase of sampling, 41 surface chemistry samples were collected at 34 stations. Samples were analyzed for base/neutral/acid organic extractables (BNA), pesticides, PCBs, metals, and conventional parameters. For further information see the Duwamish/Diagonal Cleanup Study report, Metro 1995.

Results from the Phase I sampling of the Duwamish/Diagonal cleanup study showed that DEHP was detected in every sample. When compared to the Washington State sediment management standards, DEHP exceeded the cleanup screening levels (CSL) in 29 samples and the sediment quality standards (SQS) in 8 samples. A few samples were many times higher than the CSL. In general, DEHP concentrations were high near the Duwamish and Diagonal outfalls and decreased with distance from the outfalls (Figure 2). This suggests that DEHP in this area was associated with discharges from these outfalls or historic discharges from a drainage ditch that was used for stormwater before the current stormwater outfall was installed. However, three stations upstream showed much higher concentrations than surrounding stations, suggesting another contamination source. Possible sources for this upstream hotspot include the former Diagonal Way sewage treatment plant outfall, the Diagonal Avenue South stormdrain outfall, or the remnants of a contaminated shoal that was dredged in 1984.

It is interesting to note that while DEHP is a EPA priority pollutant, Oregon, Idaho and British Columbia do not have phthalate esters listed for their marine sediment cleanup standards.

COMMERCIAL APPLICATION OF PHTHALATES

Phthalates have been used as plasticizers since the 1930s with 25 percent of the total production being DEHP, which is one of the lower cost plasticizers available. A plasticizer is added to plastic to make it soft and pliable. Therefore as a general rule, the softer or more flexible the plastic, the more plasticizer it contains.

The majority of DEHP's use (87 percent) is in the manufacture of polyvinyl chloride (PVC) resins. Other non-plasticizer uses of DEHP account for only 8 percent of

total production. However, it is used as an additive in a variety of products including cosmetics, paper products, inks, paints, and detergents.

The KC Metro Industrial Waste section (IW) is federally required to monitor and regulate companies in a wide variety of industries, including the metal finishing industry, that generate large volumes of wastewater. IW analyzes for TTOs (total toxic organics). TTOs consist of volatile organic acids and BNAs, which include the six separate phthalate types. DEHP was detected in over half the samples that were analyzed for BNA parameters. The following industry types have DEHP in their treated wastewater of over 100 ppb in 1995, listed in order of magnitude: (number in parentheses indicates number of different companies within that industry.)

Industry Type	Concentration in ppb
Commercial Laundry	314 & 1510
Can Manufacturing	1230
Hazardous Waste Treatment Facility	320 & 887
Screen Print Washing	229
Waterfall Paint Spray Booth	200
Film developing	146
Landfill leachate	144
Metal finishing Pretreatment (8)	114-391

HEALTH AND SAFETY CONCERNS OF PHTHALATES

When used in plastics, phthalates are not bound chemically to the polymer. Therefore, they tend to leach to the surface of the plastic where they can be released into the environment. This is particularly true of plastic containers and flexible packaging for fatty foods such as dairy and meat products. Levels as high as 114 mg/kg were found in soft cheese which prompted the food industry to voluntary curtailed the use of DEHP. This eventually led other food companies that used only trace amounts in their packaging to follow suit. (Mars Candy stopped using phthalates in wrappers in 1990.)

DEHP was used prior to 1979 in flexible plastic and vinyl products that were used in direct human contact, such as infant pacifiers. Many studies have found that PVC bags for blood and plasma storage leached up to 109 ppm of DEHP after only 72 hours. It does not appear that a substitute for DEHP in this application has been made.

Safety issues, such as the interior fogging of windshields caused by off-gassing of DEHP, prompted the U.S. automotive industry to discontinue DEHP use in dashboard manufacturing. Extensive toxicological studies have been conducted and abstracts from the Silver Platter Data Base are enclosed in the reference guide.

ENVIRONMENTAL CHARACTERISTICS OF PHTHALATES

When DEHP is released into aquatic environments it will biodegrade fairly rapidly (half-life 2-3 weeks) following a period of acclimation. It will also strongly adsorb to sediments and bioconcentrate in aquatic organisms. However, anaerobic conditions in water/sediment samples taken from lakes and ponds showed that virtually no degradation occurs.

DEHP has a very low vapor pressure that suggests it will not evaporate from soil and water. A calculated half-life of evaporation from water of 15 years has been reported. [R115]

Studies suggests that acclimation is very important to the biological breakdown of DEHP. [R107] If DEHP adsorbs to solids and then is discharged to a body of water, the heavier material drops out of the water column and may be covered by other deposits, in effect entombing the sediments, and thus preventing oxygen exposure and degradation. However, if DEHP is adsorbed to lighter particles that stay in suspension longer, then it will have more available dissolved oxygen to naturally degrade.

Phthalates that are present in stormwater or CSOs will be attracted to silts, oils or solids that are present in the effluent. Therefore, the dirtier the effluent, the more solids for the phthalates to adsorb to and settle out into an anaerobic sediment environment.

OTHER PHTHALATE STUDIES

Many studies have been conducted to determine how prevalent DEHP is in industry and the environment throughout the world. A summary of some of the study results is as follows:

- ***Surface water*** Mississippi River in parts per trillion. Lake Itasca, Mn: 190. Cairo, IL: 84. South of Memphis,Tn: 350. New Orleans, La: 64. [R119]
- ***Seawater*** (Averages in ppt) Gulf of Mexico: 112. Galveston Bay, Tx: 600 [R120]
- ***Rainwater*** (Averages in ppt) North Pacific: 55 College Station, Tx: 2.6 [R121]
- ***Sediments*** (Averages in ppm) European Rivers: 35. Mississippi River Delta: .069. Gulf of Mexico: .004. Galveston Bay, Texas: .022. Chesapeake Bay: .079. [R123]
- ***Treated Industrial Effluent*** (Mean in ppb) Car washes and Laundries: 440. Coal Mining;: 940. Foundries: 1100. Water-based paint manufacturing: 400. Ink manufacturing: 12,500. [R122]

King County conducted a study of vactor decant sediments. The samples for the King County study were specific to zoning types such as commercial, industrial, and single

and multi-family areas. Other studies have shown that industrial areas have higher background levels of DEHP. However, the King County study found that DEHP median concentrations were lower in industrial areas than all others except single family areas. Additionally, DEHP showed the least frequent detections in industrial areas than any other area (Figure 3).

In 1994, the City of Seattle sampled and analyzed sediment from within the Diagonal stormdrain system (Figure 4). DEHP was detected in three out of four samples, ranging from 1.7 to 11 ppb dry wt. (Figure 5) These concentrations were within the range found in the King County study for industrial areas.

DUWAMISH/DIAGONAL CLEANUP STUDY AREA

The Duwamish/Diagonal area has gone through extensive modifications in the last 60 years. An aerial photograph in 1936 revealed that the northern boundary, which is at present Port of Seattle property, was a tidal marsh (Figure 6). To the north of present location of the Diagonal stormwater outfall was a well defined slough that later served as a drainage ditch for raw sewage from the northern portion of the Henderson-East Marginal Way drainage basin (Figure 7). This drainage ditch was present until the construction of the Diagonal stormwater outfall that covered it in 1969.

Extensive shoreline alterations and dredging occurred during the past 25 years. A comparison of aerial surveys shows many modifications like the creation of a small inlet and particularly the straightening and extending of shoreline located at the Port of Seattle's Terminal 106 just north of the Duwamish/Diagonal outfalls.

In 1965, the Duwamish siphon and CSO outfall construction were completed. The siphon runs under the river and connects the Duwamish drainage basin on the west side of the river to the Elliott Bay Interceptor pipeline and Duwamish pump station on the east side of the river. Trenching and backfilling during construction altered the original sediment deposition near the mouth of the historic drainage ditch, making it appear that the consistent pattern of DEHP contamination associated with the top 10 cm of sediment near the Duwamish/Diagonal outfalls must have been deposited after 1965.

In 1989, the LaFarge Cement Company built a cement plant at the former Diagonal Avenue treatment plant site. The cement company also dredged the river bottom and constructed a pier in the proximity of the former treatment plant outfall for barge berthing. All of these actions could substantially alter original sediment depositions and therefore make it impossible to determine a historical source of contamination.

Basin Profile

The Duwamish/Diagonal drainage basin covers approximately 1287 acres with over half being commercial, light industrial and the remainder being part of the Beacon Hill neighborhood, which is east of a 3.5 miles stretch of I-5 (Figure 8). A survey of businesses within this basin reveal no particular concentration of any industry type.

Industry types in the area that could have concentrations of DEHP in their wastewater's are as follows:

- Commercial laundromats
- Screen printing
- Carwashes
- Paint and coating formulators
- Pressure washing using industrial soaps
- Restaurant (dishwashing)
- Commercial/residential carpet cleaning

SOURCE INVESTIGATION

The high levels of DEHP found during Phase I of the Duwamish/Diagonal cleanup study were the highest found anywhere within the KC Metro service area. Other areas have also shown high levels of DEHP contamination including in the sediments immediately offshore of the Denny Way CSO and in influent and biosolids at KC Metro treatment plants.

Diagonal Avenue Treatment Plant

The former Diagonal Avenue treatment plant had a capacity of 7-8 mgd of primary treatment with only a 2 hour wastewater retention time. The plant was taken over by Metro around 1962 from the City of Seattle and was operational until 1970 when the final stage of the Elliott Bay Interceptor pipeline was completed and the flows diverted to the West Point treatment plant. The Diagonal treatment plant treated wastewater from the Seattle's primary industrial core, and was considered one of the most overloaded plants in the Seattle system. It frequently by-passed untreated sewage into the Duwamish during rain events due to the combined storm and sewer system. From approximately 1964 until the completion of the Elliott Bay Interceptor pipeline, the plant also treated undigested sludge from the newly completed Renton treatment plant. Modifications that were planned in 1960 to handle this additional capacity were never completed. This resulted in a large amount of highly concentrated total suspended solids, with a very high biochemical oxygen demand being discharged to the Duwamish River.

Because the Duwamish/Diagonal cleanup study and current analysis of treatment plant biosolids show significant levels of DEHP, it is possible that the contamination near the former Diagonal Avenue treatment plant outfall was caused by inadequate sewage treatment at the former treatment plant. Sediments near the former outfall have the highest heavy metal contamination in the study area. This could be expected because the former treatment plant serviced the primary industrial area in Seattle and operated at a time with no environmental regulations.

However, the center of the main DEHP contamination is approximately 500 feet north, and appears to be associated with the Duwamish/Diagonal outfalls. In the area between the two outfalls, DEHP concentrations decrease with distance from the Duwamish/Diagonal outfall. Also, it now appears that the area where high metals and other contaminant concentrations were found offshore of the former treatment plant outfall may be the remains of a shoal dredged by the Army Corps of Engineers in the mid 1980s. Relatively low levels of DEHP contamination near the former treatment plant outfall would discount the treatment plant as a source of DEHP contamination (Figures 1 and 2).

Biosolids & Treatment Plant Loading

The Renton Treatment Plant handles the majority of newer construction for King County either through direct connection or indirectly through septage haulers. Since DEHP is the primary plasticizer used in PVC, and its tendency to off-gas, one would surmise newer residential/commercial construction using PVC wastewater plumbing could emit a higher level of DEHP. However influent and biosolids readings for both treatment plants are virtually identical.

DEHP was detected in all biosolids samples and showed the highest readings of all trace organic compounds analyzed for at both the Renton and West Point treatment plants. Some seasonal variation is apparent with the "wet" months showing lower readings. Typical influent readings for DEHP averaged around 20 ppb and effluent is less than 5 ppb.

Biosolids levels in 1994 for both plants ranged from 21-198 ppm, with a yearly average of around 100 ppm (Figure 9).

Biodegradation studies have been conducted on anaerobic digestion of municipal sludge for various organic compounds. While other phthalate compounds were removed at efficiencies of greater than 90%, DEHP was only removed between 55-65 percent efficiency. However, under aerobic conditions, such as activated sludge, degradation is greatly accelerated with half lives of around 20 hours being reported. [R107-5]

Phthalates at Denny Way

The Denny Way CSO has the most frequent and largest volume of overflows in the KC Metro system. In 1990, a sediment remediation demonstration project was conducted to clean up contaminated sediments and improve marine sediment quality immediately offshore of the Denny Way CSO. A 3-foot-thick layer of clean sand (or sediment cap) was placed on top of the contaminated sediments in front of the CSO outfall, isolating the contaminants from the environment. Part of the capping project was a 10-year monitoring program that was designed to determine how well the sand cap performed and to monitor any recontamination that may occur.

After five years of monitoring the sediment cap, DEHP had recontaminated the cap and exceeded the CSL at two of the four monitoring stations. All other contaminants were less than 60 percent of the SQS.

Phthalates in Detergents

A search of industry types in the Diagonal basin showed that there were no large users or distributors of DEHP. Therefore, DEHP contamination is possibly from a non-point source. It is possible that a popular product contains significant amounts of this compound and is being washed into to the storm drain or sewer system.

To investigate further point sources by verifying that no illegal storm drain hook-ups exist within the basin from identified industries would have been time consuming, and extensive testing for DEHP in a variety of wastewater would have been expensive. Therefore, a BNA analysis was conducted on laundry washwater and simulated carwash water, which used Dawn liquid detergent. The analysis of the laundry water, as expected, detected all six phthalate compounds with the highest being DEHP. Two phthalates were detected in the carwash water but neither was DEHP (Figure 10).

High phthalate concentrations in laundry detergent are quite likely to be a source of phthalates found in the treatment plant influent and biosolids, and on the Denny Way sediment cap. Phthalates are added to laundry detergent as a de-foaming agent. Therefore, the less a detergent foams, the higher the phthalate content. Although a BNA analysis was not run on automatic dishwasher detergent, it is suspected that phthalate concentrations would be even higher because of the lower foam requirements of automatic dishwashers. The detergent used in the carwash water was not formulated for use in an automatic dishwasher, is not used in a non-foaming application, and therefore, did not contain as many phthalates in high concentrations.

While high phthalate concentrations in non-foaming detergents are a likely contributor to high phthalate concentrations in the KC Metro service area, this does not completely explain why DEHP concentrations were higher in the Duwamish/Diagonal outfall sediments than in other outfall sediments. The chance of multiple point sources contributing to the contamination is always a possibility, but Diagonal-drainage-basin business area profile is typical of other drainage basins. Another possibility is illegal point source discharges.

Janco United

The potential major source of phthalates and other contaminants to the Duwamish/Diagonal outfall sediments originated from a janitorial chemical supply company that was formerly located on 4412 Fourth Avenue. Janco-United Incorporated formulated and repackaged a variety of commercial grade cleaners from concentrate.

To avoid the Metro Industrial Waste permitting process, Janco-United decided to dump spent chemicals and rinsate out their back door by a railroad spur line. This went on for some years until the railroad complained that the soggy area could cause damage to their rail line. In the summer of 1982 Janco employees were instructed to bury a clandestine drain line and connect it to a roof drain that led to the Diagonal storm drain. For approximately every working day for 27 months, concentration of chemicals ranging from dilute rinsate to discontinued concentrated product were discharged out the back door

and down the clandestine drain line. This practice was stopped in December 1984 when the company moved to another location. EPA was tipped off by an employee who was concerned about adverse exposure to various chemicals (Figure 11). EPA conducted an investigation and analyzed soil and standing water samples around Janco-United's dock area (Figure 12). This led to formal charges with fines and jail time for two company executives. Janco-United was acquired by another company in 1987.

Many other more harmful organics were also discharged at this site such as ethylbenzene and chloroform. Below is a summary of the analysis for the phthalate ester group. It is important to note that the BNA laboratory method at the time was isotope dilution with reporting detection limits ranging from 200-1000 ppb. These detection limits are higher than analyses that are run today. Only bold face numbers indicate significant compound readings. [S9]

Table 1. Results of EPA Investigation of Janco United

Results in PPB	Liquid near RR track		Soils samples near RR tracks		Liquid in Storm Drain	Soil NE	Soil SE	Inside drain
Sample Number	4600	4601	3200	3201	4605	4602	4603	4604
Sample Date	12/5/84	12/7/84	10/1/84	10/1/84	12/6/84	12/7/84	12/7/84	12/6/84
% Solids			68.10%	71.50%		95%	72.20%	
DEHP	500	500	**95,000**	**17,000**	**880**	1000	1000	**2500**
Butyl Benzyl Phthalate	200	200	200	200	**5200**	1000	1000	**15,000**
Di-n-Octyl Phthalate	200	200	200	200	200	1000	1000	200
Di-n-butyl Phthalate	**1,900,000**	**2,600,000**	**75,000**	**170,000**	**3,000,000**	**85,000**	**350,000**	**9,400,000**
Diethyl Phthalate	200	200	200	200	200	1000	1000	200
Dimethyl Phthalate	200	200	**530**	200	200	1000	1000	200

These numbers, especially the liquid phase, represent a snapshot of the most recent discharges prior to sample collection. While Di-n-Butyl Phthalate showed the highest concentrations, it is possible that this didn't affect the outfall sediments because of the higher biodegradation rates for Di-n-Butyl and other phthalate esters versus DEHP in anaerobic conditions.

From where Janco-United is located, the chemicals would flow about 1 mile to the river with a total vertical drop of only 3 feet (Figure 13). This section of the Diagonal drainage pipe is large in diameter and has a deep invert of approximately minus 10 feet. There are also no diverters or weirs to prevent a constant tidal influence. This non-turbulent condition would not volatilize (off-gas) the organics. Low turbulence would also limit acclimation, which would limit the breakdown of DEHP. The tidal influence in the stormdrain would also allow upstream contaminated sediments in the pipe to migrate out the outfall.

Additionally, wastewater and sewage that contain even high concentrations of DEHP would not likely cause the high concentrations in Duwamish/Diagonal sediments because the turbulence associated with a CSO event would probably volatilize or acclimatize and degrade some fraction of the DEHP. CSO events at the Duwamish outfall have also been reduced to an average of less than one per year.

The dumping of concentrated product that contains a high proportion of DEHP, the low turbulence and anaerobic environment of the tidally influenced Diagonal stormdrain, and that DEHP doesn't degrade in an anaerobic environment likely account for the high concentrations of DEHP in the Duwamish/Diagonal sediments.

Other Areas Studied During This Investigation

The following areas were studied based on product use, DEHP content, and likelihood of runoff or wastewater entering the storm drains.

PVC Plumbing. Some leaching from PVC plumbing does occur, but it happens very slowly over a long period of time. No studies have been conducted to date, however. It is likely that DEHP leaching from PVC plumbing would be difficult to detect.

Plastic Injection Molding. Most plastic injection molding companies have moved to the Kent Valley. Also, water is not used in the injection process for cooling or cleaning. Harder plastics require less plasticizer and have less chance of leaching any phthalates into surface water. DEHP is mostly associated with flexible, softer, and more inexpensive grades of PVC plastics.

Automotive Tires. Vehicle tires were initially suspected because large amounts of dust solids, which are produced as tires wear out, could wash from streets and into stormdrains. However, a spokesperson from the University of Akron (Ohio) Tire Institute said that the plasticizer for tires consist of higher quality styrene and butadiene based polymer compounds.

PCB Substitute. The National Toxicology Program reports that the only significant non-plasticizer use for DEHP is as a replacement fluid for polychlorinated biphenyls (PCBs). Scientists at Seattle City Light, who have conducted numerous studies on PCBs, could find no support for this claim. Also, no correlation exists between PCB and DEHP contamination in other sediment studies areas.

Paints and Coatings. The National Toxicology Program also reported that DEHP is added to latex-based paints. Preservative Paints in Seattle was contacted to confirm this. According to Preservative Paints, DEHP is not water miscible and therefore not added to latex-based formulations. Currently, Preservative Paints incorporates about 1 percent by weight of DEHP in alkyd (oil) industrial medium grade paints to improve flow qualities and add flexibility to the finish. DEHP is not used in heavy applications such as traffic and bridge paint, and it has limited use for industrial grade emulsion based (oil/water) paints. It is used in some clear satin oil varnishes for wood.

CONCLUSION

While it appears that Janco-United's action is the primary cause for the DEHP contamination in the marine sediment at the Duwamish/Diagonal outfalls, many other factors could have a cumulative effect. Since DEHP is so common throughout the environment, "source control" efforts may be difficult or impossible.

In tests, soaps and detergents have shown high levels of DEHP and have easy routes to storm drains from many sources, including car washing and carpet cleaners discharging solutions in the street. More study would be useful to further correlate DEHP concentrations in raw sewage and stormwater with DEHP concentrations in household products. In particular, a BNA analysis of automatic dishwashing soap may be useful.

As the studies show, DEHP will biodegrade more quickly in a liquid phase or in aerobic conditions. If allowed to attach to sediments and/or become anaerobic, degradation will slow considerably. Reducing solids loading before stormwater or wastewater reaches an outfall could significantly reduce future DEHP contamination. Sediment retention chambers installed in larger storm drains would allow heavier material to drop out and hopefully halt the migration of DEHP to the environment. DEHP attached to lighter colloidal particles would not have the same effect on the environment because they would remain in suspension, where oxygen is more available to assist in the degradation process.

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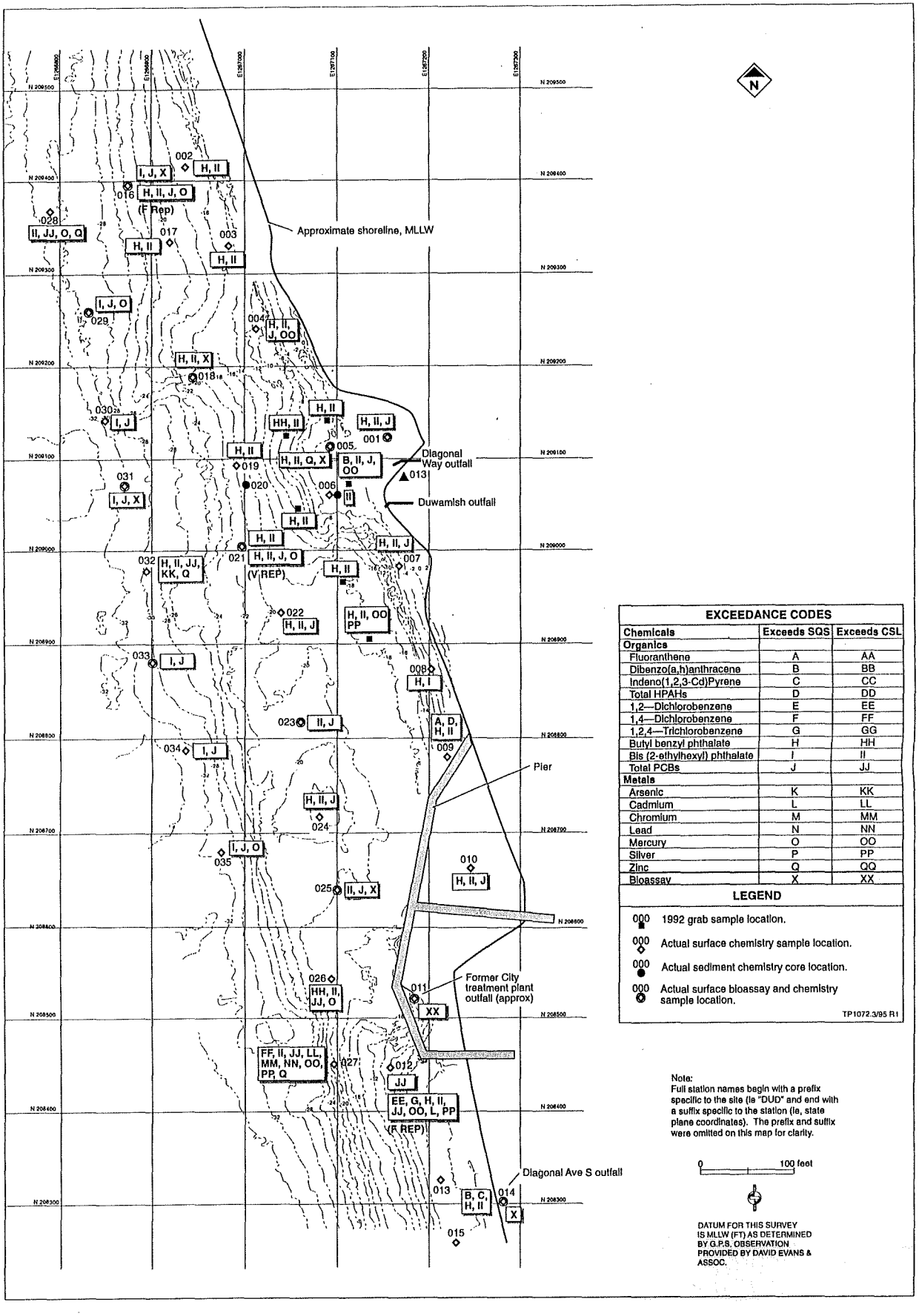

Figure 1.

Duwamish/Diagonal with Codes of Chemicals that Exceed Sediment Standards at Each Station

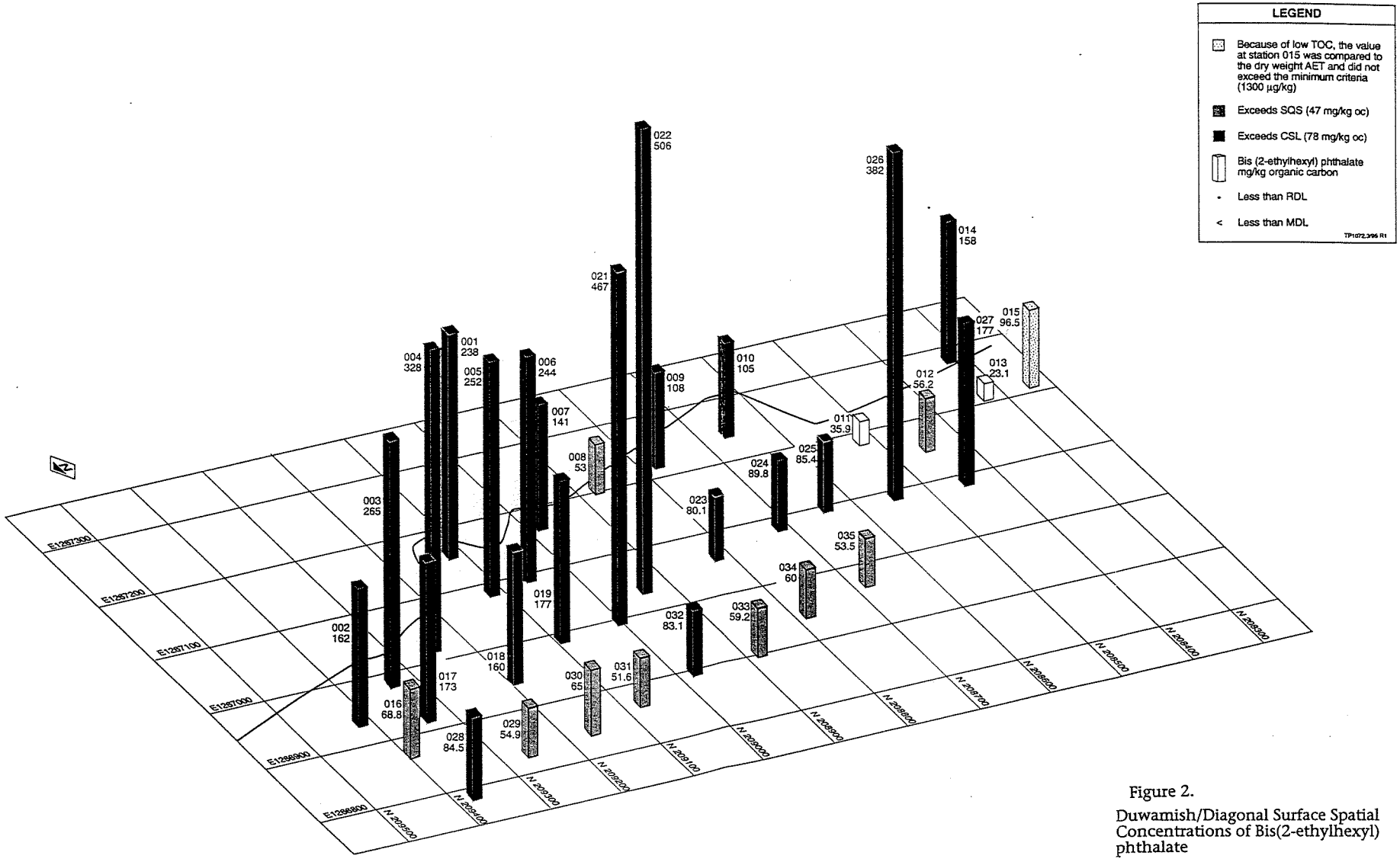

Figure 2.

Duwamish/Diagonal Surface Spatial Concentrations of Bis(2-ethylhexyl) phthalate

Table 18. Statistical summary of organic compound analyses of vactor solids samples.

Combination of Single & Multi-family Commercial & industrial

	All Land Uses							
	D[a]	Median	Range	CI Range[b]	S[c]	Median	Range	CI Range[b]
Parameter (ug/kg)	Detected Values Only				All Samples			
1,1,1-Trichloroethane	2	422	(33- 810)	undefined	72	4	(3- 810)	(3- 4)
1,1,2-Trichloroethylene	3	160	(13- 310)	undefined	72	4	(3- 310)	(3- 4)
1,1-Dichloroethane	2	275	(190- 360)	undefined	72	4	(3- 360)	(3- 4)
2-Butanone (MEK)	7	50	(30- 130)	(30- 100)	72	20	(15- 500)	(20- 20)
Acetone	31	109	(40- 610)	(70- 130)	72	20	(15- 610)	(20- 40)
Benzene	4	43	(8- 65)	undefined	72	4	(3- 100)	(3- 4)
Chloroethane	1	7	(7- 7)	undefined	72	4	(3- 100)	(3- 4)
Ethylbenzene	23	35	(7- 2100)	(10- 87)	72	4	(3- 2100)	(4- 4)
Methylene Chloride	7	210	(160- 4500)	(160- 260)	72	20	(15- 4500)	(20- 20)
Styrene	2	15	(10- 20)	undefined	72	4	(3- 100)	(3- 4)
Tetrachloroethylene	5	210	(62- 24000)	undefined	72	4	(3- 24000)	(3- 4)
Toluene	55	150	(8- 83000)	(89- 160)	72	81	(3- 83000)	(40- 140)
Total Xylenes	34	46	(7- 22000)	(16- 270)	72	5	(3- 22000)	(4- 10)
2-Methylnaphthalene	37	380	(77- 5425)	(250- 570)	72	105	(20- 5425)	(50- 200)
4-Methylphenol	28	480	(75- 7200)	(285- 780)	72	63	(10- 7200)	(50- 120)
Acenaphthene	55	180	(18- 4000)	(130- 360)	72	108	(15- 4000)	(88- 160)
Acenaphthylene	9	35	(10- 100)	(20- 81)	72	35	(5- 350)	(30- 35)
Anthracene	61	280	(10- 11000)	(190- 370)	72	195	(10- 11000)	(132- 310)
Benzo(a)anthracene	71	830	(69- 32000)	(540- 1000)	72	823	(35- 32000)	(510- 1000)
Benzo(a)pyrene	60	855	(65- 26000)	(620- 1300)	72	720	(45- 26000)	(335- 880)
Benzo(b)fluoranthene	60	1550	(98- 38000)	(1100- 1800)	72	1200	(20- 38000)	(675- 1600)
Benzo(g,h,i)perylene	41	770	(84- 25000)	(425- 1200)	72	235	(10- 25000)	(50- 420)
Benzo(k)fluoranthene	60	685	(40- 18000)	(470- 920)	72	510	(20- 18000)	(350- 690)
Benzoic Acid	12	1218	(150- 4100)	(420- 2200)	72	200	(45- 4100)	(200- 200)
Benzyl Alcohol	2	224	(97- 350)	undefined	72	50	(10- 500)	(50- 50)
Benzyl Butyl Phthalate	46	620	(90- 17000)	(320- 750)	72	250	(5- 17000)	(140- 350)
Bis(2-Ethylhexyl)Phthalate	67	4750	(660- 45600)	(3300- 6100)	72	4300	(5- 45600)	(3200- 5650)
Carbazole	45	600	(51- 9000)	(250- 1200)	72	175	(10- 9000)	(100- 280)
Chrysene	71	1020	(90- 34000)	(700- 1300)	72	1010	(35- 34000)	(650- 1300)

[a] D-Number of samples where constituent was detected at concentration above detection limit.

[b] Represents the 95-percent confidence interval (CI) range around the median.

[c] S-Number of samples analyzed; statistics based on values below detection limit entered as one-half detection limit.

Figure 3. King County Vacator Sediment Sample Results.

CITY OF SEATTLE

Diagonal Outfall Sediment samples

April 06, 1995
Produced by the
Seattle Engineering Department,
Geographic Systems

Legend

- Drainage Mainlines
- Culverts
- Sewer Mainlines
- Streams
- • D056-126 Sediment sample site (storm drain)

Scale 1" = 500'

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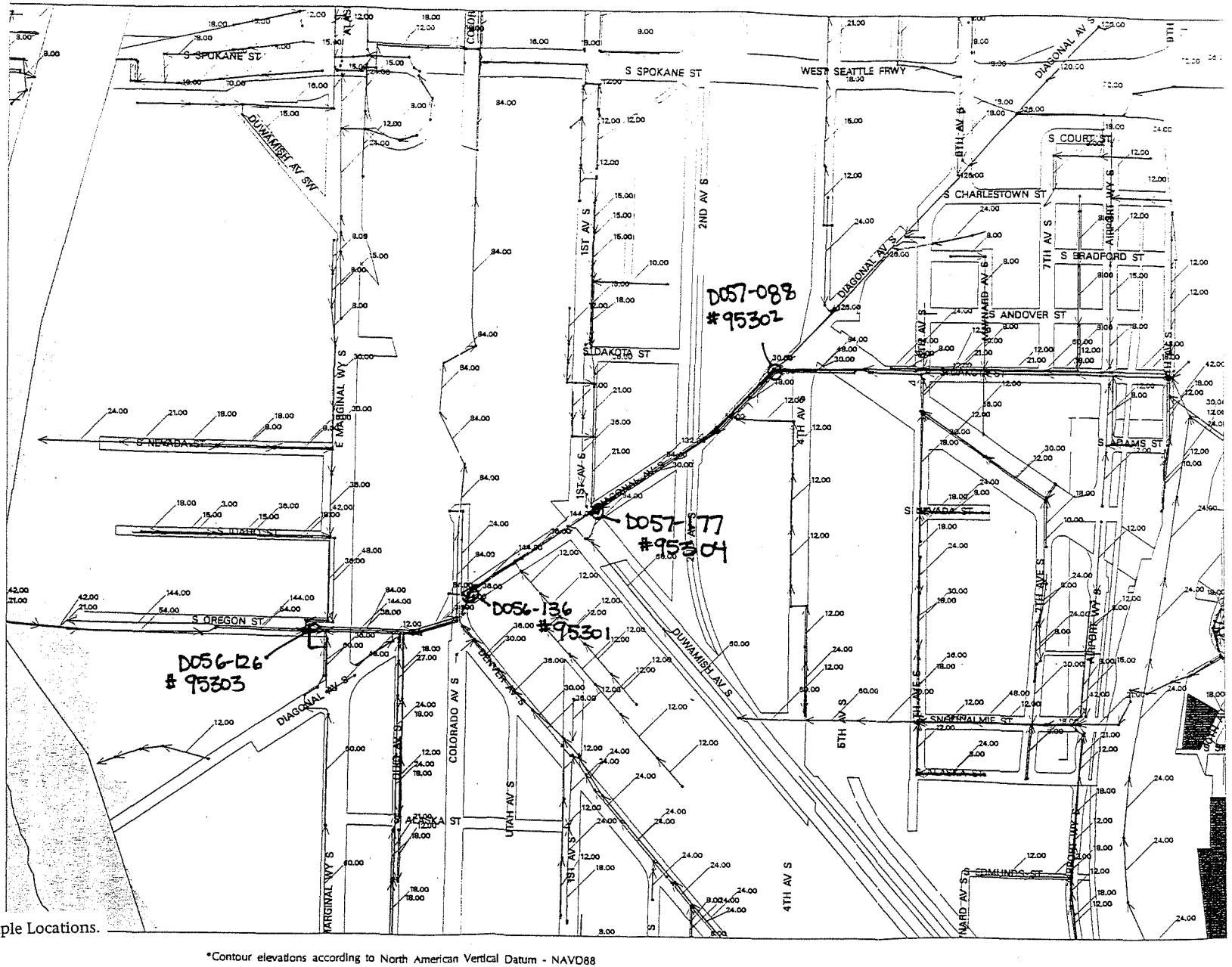

Figure 4. City of Seattle Stormdrain Sample Locations.

/dwru3/dwrumap/misc_dwru/generic/dpa.aml

*Contour elevations according to North American Vertical Datum - NAVD88

Diagonal Storm Drain Pipe Sediment Samples					
					SQS
Station	D056-136	D057-088	D056-126	D057-177	
Sample No.	95301	95302	95303	95304	
% Solids	84	24	75	85	
TOC, dry %C	0.24	8.8	1.5	0.37	
Pesticides & PCBs, dry wgt, ug/kg					
4, 4'-DDD	<RDL 3.4	19	4	<RDL 3.4	
4, 4'-DDE	<RDL 3.4	11	<RDL 3.4	<RDL 3.4	
4, 4'-DDT	3.9	18	4.7	<RDL 3.4	
PCB-1248	<RDL 34	190	46	<RDL 34	
Semi-Volatile Organics, dry wgt, mg/kg					
Benz[a]anthracene	<RDL .30	<RDL 1.0	<RDL 0.50	<RDL 0.30	
Benzo[b]fluoranthene	0.36	<RDL 1.0	0.57	<RDL 0.30	
Benzo[a]pyrene	<RDL .30	<RDL 1.0	<RDL 0.50	<RDL 0.30	
Bis(2-ethylhexyl)phthalate	1.7	11	4.7	<RDL 1.5	
Butyl benzyl phthalate	<RDL .30	<RDL 1.0	0.62	<RDL 0.30	
Chrysene	0.38	<RDL 1.0	0.65	<RDL 0.30	
1, 4-Dichlorobenzene	<RDL .30	<RDL 1.0	<RDL 0.50	0.33	
Fluoranthene	0.72	<RDL 1.0	1.1	0.52	
4-Methylphenol	<RDL .30	9.9	<RDL 0.50	<RDL 0.30	
Phenanthrene	0.46	1.1	0.55	<RDL 0.30	
Tyrene	0.6	<RDL 1.0	1.1	0.45	
Di-n-octyl phthalate	<RDL .30	1.3	<RDL 0.50	<RDL 0.30	
4-Methylphenol	<RDL .30	9.9	<RDL 0.50	<RDL 0.30	
Metals, dry wgt, mg/kg					*mg/kg DW*
Arsenic	4.3	9	7.3	3.2	93
Cadmium	0.7	1.1	0.76	0.57	6.7
Chromiun	24	30	14	21	270
Copper	36	90	51	28	390
Lead	100	100	120	32	530
Mercury	0.018	0.12	<RDL 0.01	0.033	0.59
Silver	0.56	<RDL 0.71	0.67	0.49	6.1
Zinc	150	320	170	170	960

Figure 5. City of Seattle Stormdrain Sample Results. (1994)

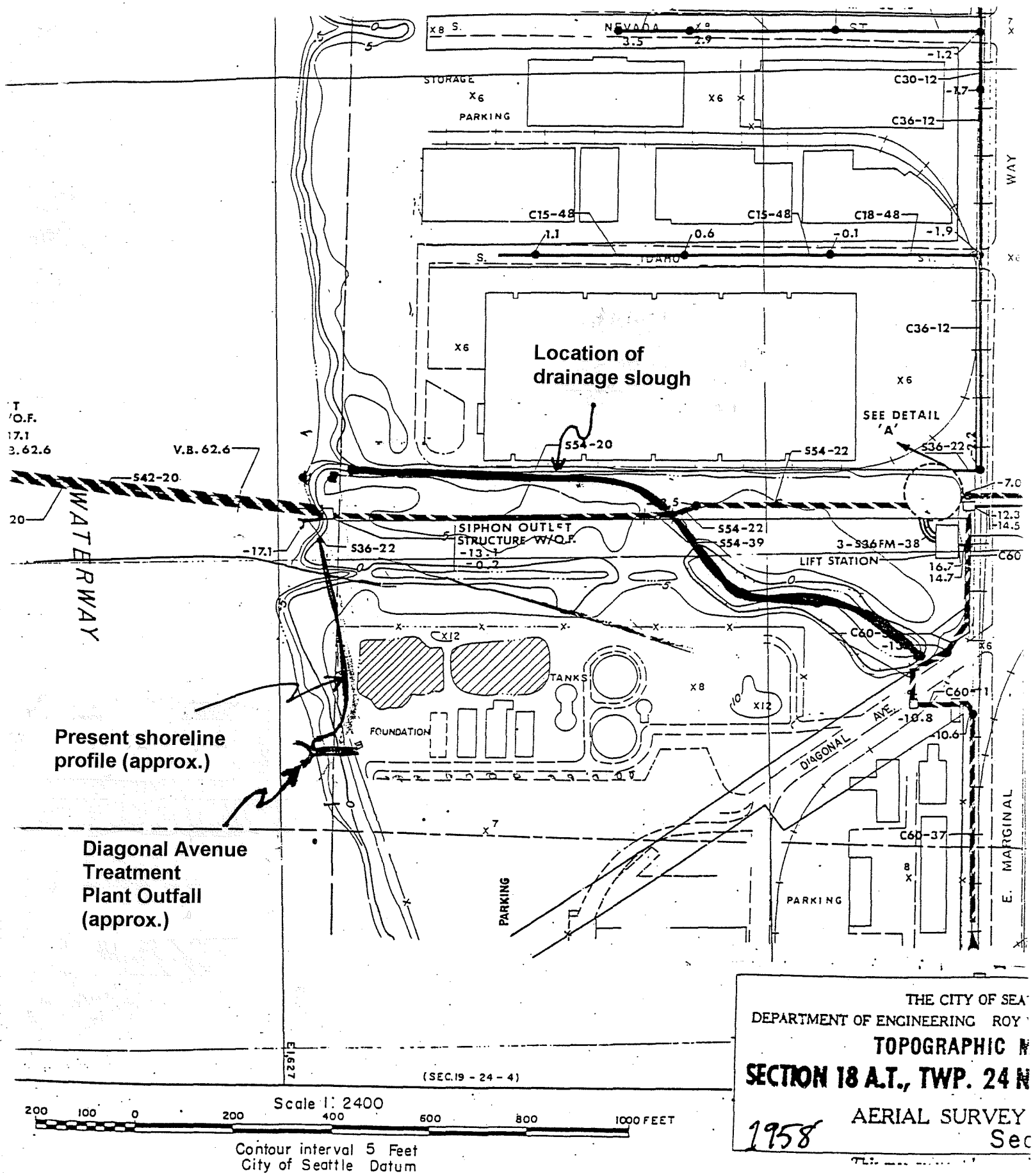

Figure 6. Aerial Survey Map

Dry weather flows are conveyed from the Lake Washington watershed around the south end of Beacon Hill to East Marginal Way. Flows from parts of the heavily industrialized Duwamish valley, including 470 acres outside the city, are intercepted along East Marginal Way and discharged into the Michigan Street trunk sewer (No. 147). Here a regulating station (No. 109) diverts up to 6.5 mgd through Nos. 108 and 107 to the Diagonal Avenue treatment plant. Since sections of the intercepting sewer have only about 10 per cent of the capacity of tributary trunks, up to 90 per cent of the wet weather flow is bypassed at various locations. Three small systems, as well as a number of industries, discharge directly to the Duwamish.

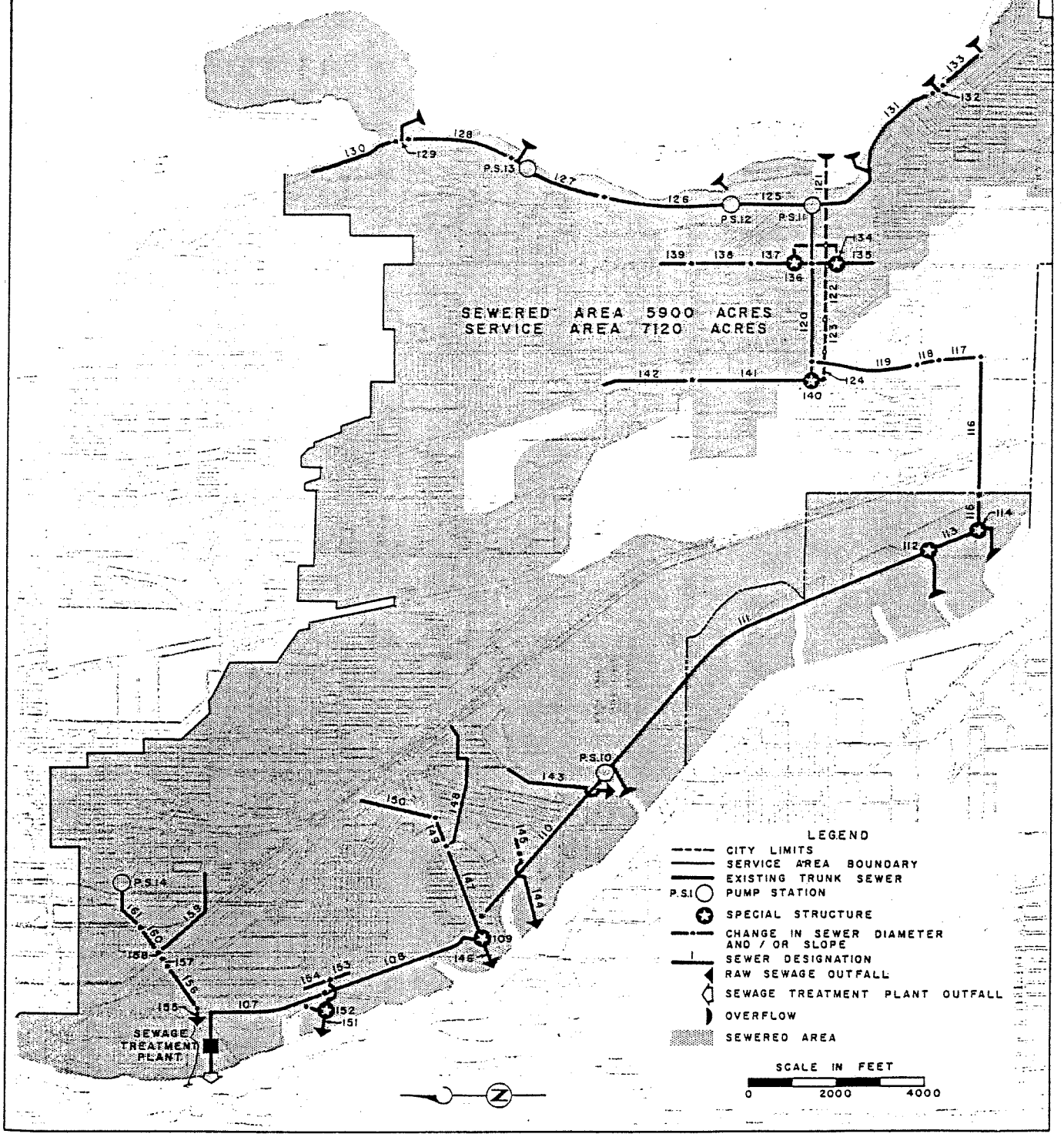

Figure 7. **Henderson - East Marginal Way System**

CITY OF SEATTLE

DIAGONAL/ HANFORD DRAINAGE BASIN

Legend:

- Diagonal Basin
- Hanford Basin
- Storm Mainlines
- City Boundary
- Streets
- Water

Produced by Seattle Engineering Department's Drainage and Wastewater Utility, March 30, 1995.

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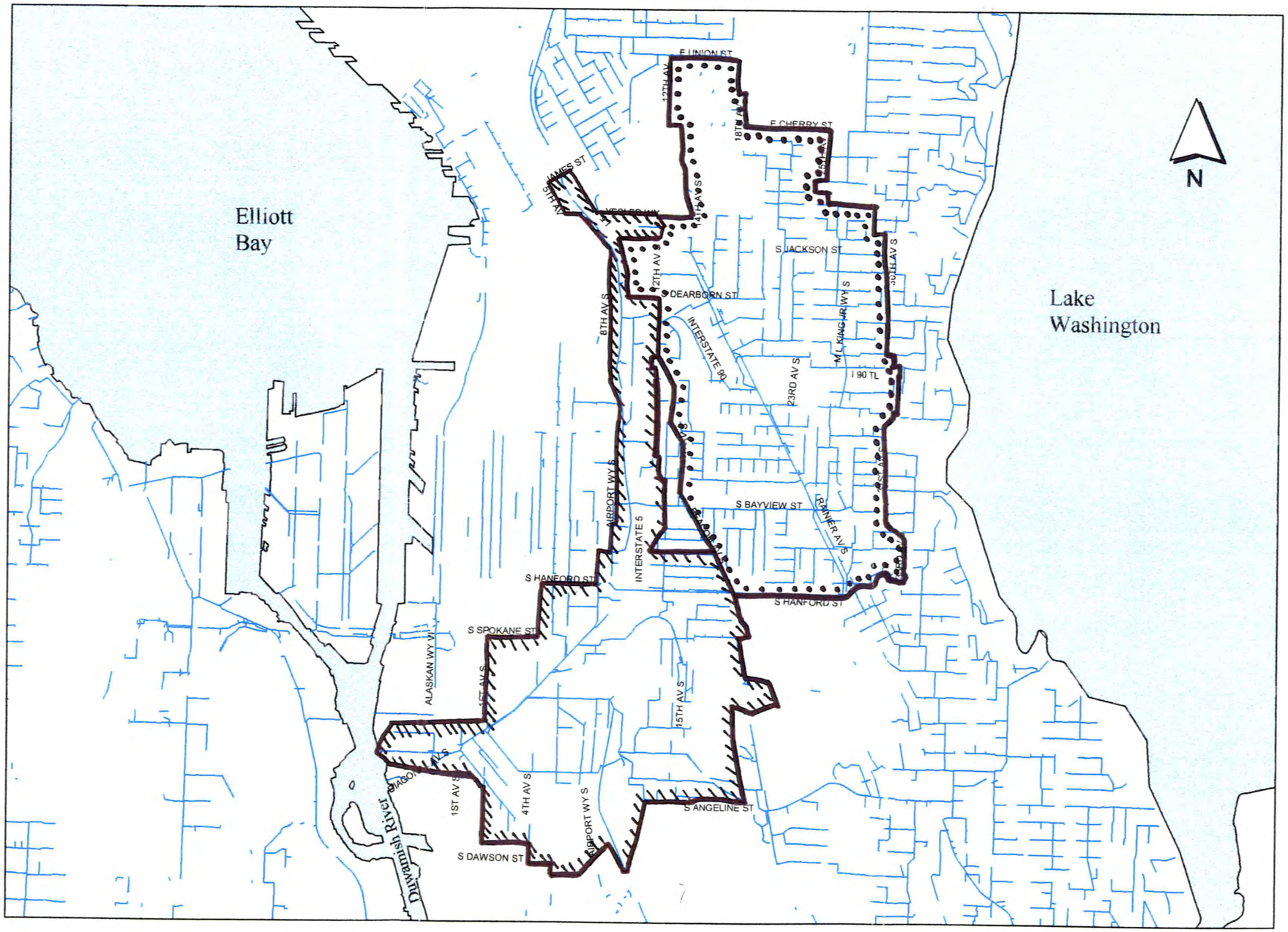

0.5 0 0.5 1 Miles

Figure 8

METRO Environmental Lab Analytical Report

PROJECT: B53403

Locator:	NONE	NONE
Client Loc:	Laundry Wash	Car Wash (Dawn Detergen
Sampled:	Nov 07, 95	Nov 08, 95
Lab ID:	L7263-1	L7263-2
Matrix:	OTHR WTR	OTHR WTR
% Solids:		

Parameters	Value	Qual	MDL	RDL	Units	Value	Qual	MDL	RDL	Units
		- Wet Weight Basis					- Wet Weight Basis			
Benzo(g,h,i)perylene		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Benzo(k)fluoranthene		<MDL	15	28.3	ug/L		<MDL	7.5	14.2	ug/L
Benzoic Acid	49	<RDL	38	56.6	ug/L		<MDL	19	28.3	ug/L
Benzyl Alcohol	21		9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Benzyl Butyl Phthalate	25.8		5.7	9.43	ug/L	14		2.8	4.72	ug/L
Bis(2-Chloroethoxy)Methane		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Bis(2-Chloroethyl)Ether		<MDL	5.7	9.43	ug/L		<MDL	2.8	4.72	ug/L
Bis(2-Chloroisopropyl)Ether		<MDL	19	37.7	ug/L		<MDL	9.4	18.9	ug/L
Bis(2-Ethylhexyl)Phthalate	254		5.7	9.43	ug/L		<MDL	2.8	4.72	ug/L
Carbazole		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Chrysene		<MDL	5.7	9.43	ug/L		<MDL	2.8	4.72	ug/L
Coprostanol		<MDL	38	56.6	ug/L		<MDL	19	28.3	ug/L
Di-N-Butyl Phthalate	108		9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Di-N-Octyl Phthalate	77.1		5.7	9.43	ug/L		<MDL	2.8	4.72	ug/L
Dibenzo(a,h)anthracene		<MDL	15	28.3	ug/L		<MDL	7.5	14.2	ug/L
Dibenzofuran		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Diethyl Phthalate	193		9.4	18.9	ug/L	55.4		4.7	9.43	ug/L
Dimethyl Phthalate	3.8	<RDL	3.8	5.66	ug/L		<MDL	1.9	2.83	ug/L
Fluoranthene		<MDL	5.7	11.3	ug/L		<MDL	2.8	5.66	ug/L
Fluorene		<MDL	5.7	9.43	ug/L		<MDL	2.8	4.72	ug/L
Hexachlorobenzene		<MDL	5.7	9.43	ug/L		<MDL	2.8	4.72	ug/L
Hexachlorobutadiene		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Hexachlorocyclopentadiene		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Hexachloroethane		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Indeno(1,2,3-Cd)Pyrene		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Isophorone		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
N-Nitrosodi-N-Propylamine		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
N-Nitrosodimethylamine		<MDL	38	56.6	ug/L		<MDL	19	28.3	ug/L
N-Nitrosodiphenylamine		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Naphthalene		<MDL	15	28.3	ug/L		<MDL	7.5	14.2	ug/L
Nitrobenzene		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Pentachlorophenol		<MDL	9.4	18.9	ug/L		<MDL	4.7	9.43	ug/L
Phenanthrene		<MDL	5.7	9.43	ug/L		<MDL	2.8	4.72	ug/L
Phenol		<MDL	38	56.6	ug/L	25	<RDL	19	28.3	ug/L
Pyrene		<MDL	5.7	9.43	ug/L		<MDL	2.8	4.72	ug/L

Figure 10. BNA Analysis of Detergents

Figure 9.

TABLE B-5. Organic Compounds (mg/kg dry) for West Point Dewatered Biosolids

		NEUTRALS						
Sample Number	Date	Di-n-butyl phthalate	Benzyl butyl phthalate	Benzo (A) anthracene	Chrysene	Bis (2-ethyl-hexyl) phthalate	Benzo (B) fluoranthene	Benzo (K) fluoranthene
L2750-1	10-Jan-94	<0.2	2.08	1.64	2.2	84	3	1.12
L2950-1	14-Feb-94	<0.67	2.63	1.6	2.3	90	2.13	1.33
L3165-1	14-Mar-94	<0.17	3.67	1.87	2.8	127	5	2.3
L3404-1	11-Apr-94	<0.44	3.06	1.46	2.2	88.1	2.26	1.57
L3718-1	16-May-94	1.05	4.13	0.82	1.17	59	3.19	1.1
L3898-1	13-Jun-94	<0.18	3.87	1.84	1.85	77.7	2.13	0.63
L4019-1	18-Jul-94	<2.0	3.98	1.78	2.01	139	<3.3	<3.3
L4259-1	8-Aug-94	<2.0	3.71	1.91	1.87	99.2	<3.2	<3.2
L4455-1	12-Sep-94	<1.8	5	2.48	2.66	98.7	<2.9	<2.9
L4666-1	1-Oct-94	<1.9	3.96	1.91	2	130	<3.1	<3.1
L4885-1	1-Nov-94	<1.8	<1.1	<1.1	<1.1	39.7	<2.9	<2.9
L5046-1	12-Dec-94	<0.92	2.47	2.13	2.36	87.3	3.42	<1.5

TABLE B-6. Organic Compounds (mg/kg dry) for East Division Reclamation Plant Dewatered Biosolids

		NEUTRALS						
Sample Number	Date	Benzyl butyl phthalate	Benzo (A) anthracene	Bis (2-ethyl-hexyl) phthalate	Benzo (B) fluoranthene	Benzo (K) fluoranthene	Benzo(A) pyrene	Dibenzo-furan
L2750-2	10-Jan-94	0.65	0.4	90	<0.25	<0.25	<0.15	0.25
L2950-2	14-Feb-94	<0.5	<0.5	65	<1.5	<1.5	<1	<1
L3165-2	14-Mar-94	1.54	<0.15	149	<0.4	<0.4	<0.25	<0.25
L3404-2	11-Apr-94	0.847	<0.39	102	<1	<1	<0.64	<0.64
L3718-2	16-May-94	0.394	<0.16	58.7	<0.43	<0.43	<0.27	<0.27
L3898-2	20-Jun-94	0.64	0.441	125	1.13	0.535	0.678	<0.13
L4019-2	11-Jul-94	<0.17	0.808	198	0.95	1.09	<0.28	<0.27
L4259-2	8-Aug-94	<1.7	<1.7	56.8	<4.5	<4.5	<2.8	<2.8
L4455-2	12-Sep-94	<1.6	1.62	118	<4.3	<4.3	<2.7	<2.7
L4666-2	10-Oct-94	<1.7	<1.7	136	<4.4	<4.4	<2.8	<2.8
L4885-2	1-Nov-94	<1.6	<1.6	21	<4.2	<4.2	<2.6	<2.6
L5046-2	12-Dec-94	<0.8	<0.8	78	<2.2	<2.2	<1.4	<1.4

Figure 11.

Janitorial supply company faces water pollution probe

May 14, 1985
Front Page

By Steve Miletich
P-I Reporter

A Seattle janitorial supply company used a "clandestine drain pipe" to dump a cancer-causing chemical and other hazardous wastes illegally into the Duwamish Waterway, according to court documents unsealed in federal court yesterday.

At one point, the president of the firm denied knowledge of the pipe but later admitted to an investigator that he was aware of it, an Environmental Protection Agency affidavit stated.

An investigation of the alleged dumping by Janco-United Inc. is being conducted by the EPA and the U.S. Attorney's Office in Seattle.

No formal charges have been filed, but the matter is under review, Assistant U.S. Attorney David Marshall said.

Federal agents seized records from the firm at 10838 East Marginal Way S. last Friday after serving it with a search warrant.

Among the allegations contained in the EPA affidavit used to obtain the search warrant is that the president of the company, Peter Hedegard, arranged for the installation of a hidden pipe to dump wastes into the Duwamish Waterway when the company was

See ILLEGAL, Page A-6

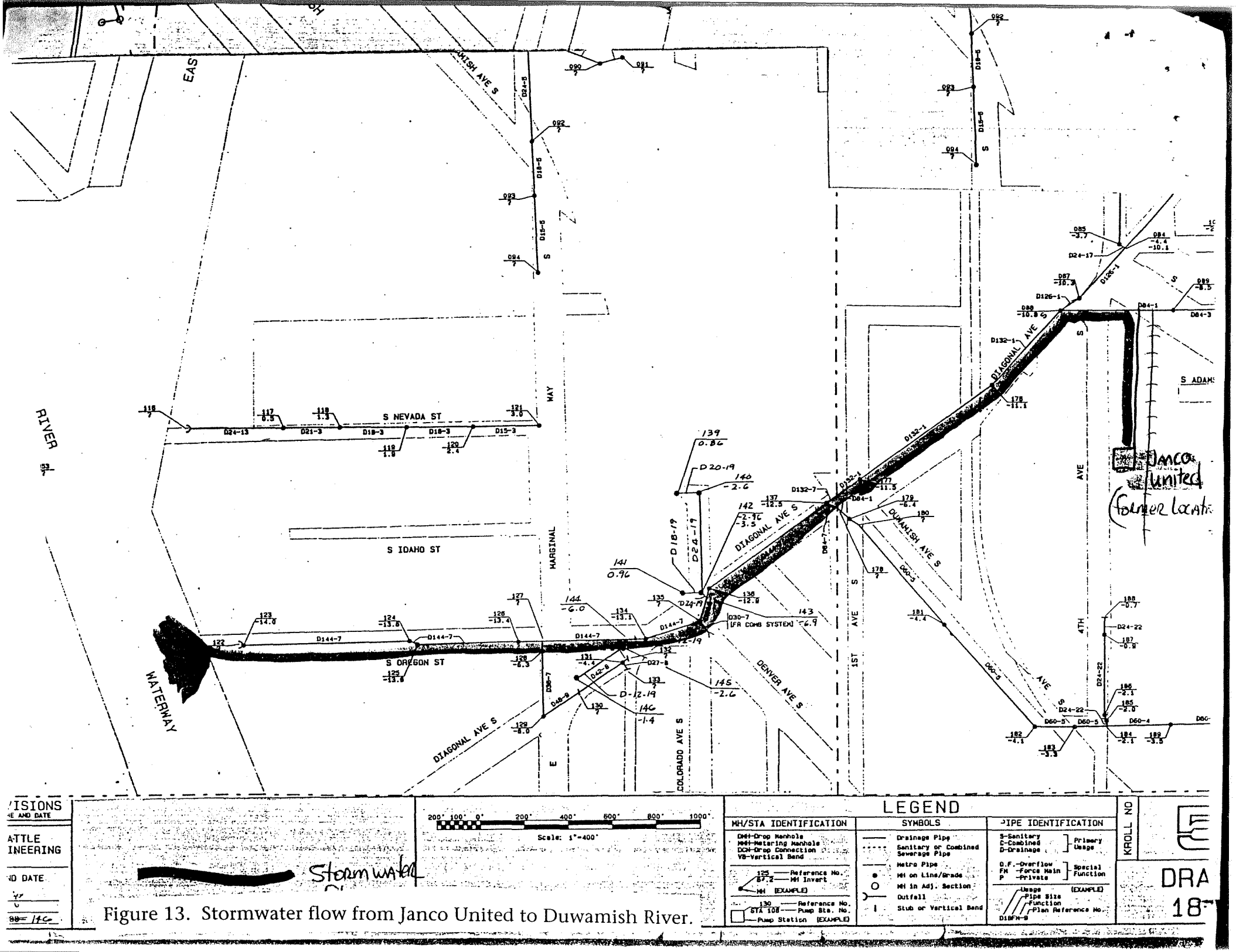

Figure 13. Stormwater flow from Janco United to Duwamish River.

Appendix H
METRO Recontamination Modeling Report

Duwamish/Diagonal Recontamination Modeling Report

Prepared for the
Elliott Bay/Duwamish Restoration Program Panel

By: Kevin Schock
and Randy Shuman

KING COUNTY

Clean Water - A Sound Investment

Introduction to Duwamish/Diagonal Modeling Report

The purpose of this modeling effort is to evaluate the likelihood of recontamination of the sediment at this site after sediment cleanup has occurred. The method used to estimate the probability of recontamination is to model the increase in concentration of toxicants on the cleaned area in the vicinity of the discharge. The necessary elements required for a model of this type is a knowledge of the concentration of toxicants in the discharge assumed to be present in the future, the volume of the discharge in the future, the behavior of individual toxicants in the sediment and the transport of toxicants from the discharge to the sediments.

The regulatory requirement for this effort is the ability to estimate whether or not the concentration of an individual toxicant will exceed the WA State sediment standards within 10 years of the time of cleanup.

A number of potential models can be used for this type of a modeling effort. The models range from simple analytical and spreadsheet models to complex numerical models that incorporate a three dimensional hydrodynamic models and detailed models of chemical behavior of toxicants. The modeling options were discussed in greater detail in the Duwamish/Diagonal Cleanup Study Workplan. The cost and effort necessary increase as the complexity of the models increase. The Sediment Working Group and the Duwamish/Diagonal Project Team decided that in the consideration of the funds available and the schedule that needed to be met that a second generation spreadsheet model would be appropriate for this effort.

The model chosen was a refinement of the SEDCAM model discussed by the Dept. of Ecology in the Sediment Cleanup Standards User Manual (1991)and was described by Jacobs, Barrick and Ginn, 1988. This model was extended by King Co. Dept. of Metropolitan Services by the additional use of partitioning coefficients and the ability to incorporate time variable loading scenarios throughout the modeling period in contrast to the constant loading of the original model. This model was referred to as METSED in the Cleanup Study Workplan.

Illegal dumping is investigated

From Page A-1

located at 4412 Fourth Avenue S. The waterway leads to Elliott Bay and Puget Sound.

The affidavit did not spell out how long the supposed dumping occurred or in what volume.

Hedegard was out of town yesterday and couldn't be reached for comment.

The company's vice president, Eric Myers, said the company disputes some of the allegations, but he declined to elaborate because the matter is under investigation.

Myers said the investigation began when a former employee contacted the EPA.

Began last June

The company mixes various chemicals into smaller containers for retail sale, including disinfectants and soaps for restaurants, solvents, floor cleaners, degreasing agents for engine parts, floor waxes and other similar products.

The search warrant affidavit, written by EPA Special Agent Commodore Mann, said the investigation began in June 1984.

Mann said he conducted surveillance at the company's old location until December 1984, when it moved to the new site.

During the surveillance, Mann said, he saw three clear hoses extending out the back door of the old plant and over a loading dock.

The hoses ran to a large black drain pipe directly under the back door, Mann said.

"The ground near the three hoses appeared to be wet, with a strong, pungent odor," he said.

Tests conducted on soil samples taken from the area showed unusually high concentrations of various chemicals listed as toxic and hazardous under federal regulations, including trichloroethane, chloroform, tetracholoreothylene, toluene and acetone.

Metro official, Mann said.

The investigation follows the recent conviction of the Wyckoff Co., a West Seattle wood treatment firm that pleaded guilty to dumping cancer-causing chemicals into Elliott Bay and Puget Sound.

Wyckoff's president, William Cairns, today is scheduled to begin serving a 60-day term in the Bishop-Lewis halfway house in Seattle for his role in the illegal dumping. He will be allowed to conduct his corporate duties during the day under a work-release arrangement.

High concentrations

In addition, Mann said, he saw company workers rinsing out 55 gallon drums and smaller plastic drums and depositing the wastes onto the ground next to the black pipe.

Tests on soil samples that were taken on a second occasion showed high concentrations of benzoic acid, benzyl alcohol, napthalene, phenanthrene, pyrene, fluroanthene, 2-propanol, acetone, 2-hexanone, styrene, 0-xylene, tetracholoethylene, trichloroethylene, benzene, chloroform and ethylbenzene.

EPA spokesman Bob Jacobson said yesterday that benzene is a known cancer-causing chemical and that many of the other substances are suspected carcinogens.

In the affidavit, Mann said Hedegard admitted during an interview on April 30 that his company routinely disposed of all its waste material from its mixing operations out the back loading dock of its former facility.

Waste disposal

At the current plant, Mann said, the company has been using a drain which discharges into a sanitary sewer system, although it has no permits from Metro or the State of Washington. The drain has since been sealed at Metro's orders.

"During my conversation with Mr. Hedegard," Mann said, "I confirmed that the company has never had any system of disposing of its liquid waste products from rinsing its mixing tanks and drums, other than by disposing out the back door."

Interviews with employees revealed that Hedegard arranged in the summer of 1983 for the installation of the black pipe, which was covered with soil and gravel, Mann said.

Hedegard initially denied any knowledge of the black pipe during the April 30 conversation, but later acknowledged that he knew about it in a conversation with a

Modeling Approach

Temporal Aspects

Two approaches with respect to chemical loading conditions are taken in this report. One looks at annual loading conditions. This is typically the approach taken to determine how much (kilograms per year) chemical is discharged into a water body over a year. It assumes that the CSO is continuously discharging at a constant rate over the year. The CSO hydrograph is averaged over one year. Real CSO's discharge sporadically, when big rain storms occur. Results from averaging techniques can differ greatly from non-averaged results.

The other approach assumes that CSO is continuously discharging at a constant rate over one week. For this, the CSO hydrograph is segmented into fifty two one week intervals, each segment is the average discharge for that week. This approach at least allows the loading rate to vary over time, which is more realistic.

Mixing Volumes

SEDCAM/METSED assumes that chemical inputs (source) are well mixed over the area of interest, or more specifically, the volume of water over the sediments. Knowing the ambient flow of water and chemical concentration entering the study volume, and knowing the discharge flow and concentration; the chemical concentration in the water above the sediment bed can be computed. The relative magnitudes of the ambient and discharge flows effects the rate at which concentrations change over time, and the ultimate concentration. If field data for the ambient and source flow is not available, then the flows into the area must be estimated.

For this report the ambient flows were estimated by the fraction of affected river width over the total width, and assuming that the river flow is evenly distributed across the channel. SEDCAM/METSED was used to estimate sediment concentrations for a fraction of river width, comparing the concentrations to the sediment quality standard (SQS). If the river width was small or if the concentrations never reached the SQS for a nominal width of one foot then recontamination would be minimal (under the modeling assumptions given later in this report).

If field data on river circulation characteristics is not available, one way to overcome this is to determine what river flow and river/discharge dilution combination will cause sediment concentrations to reach sediment quality standards. The known river flow can be used to compute the apparent width of river affected by the source that would result in a recontamination to sediment quality standard levels. If the apparent mixing width is much smaller than the expected contamination area then it could be assumed that likelihood of recontamination at the site is minimal.

The SEDCAM Model

The SEDCAM model is a simple analytical model that simulates the change in sediment chemical concentration over time. It was used in this study to estimate toxicant concentrations in the sediments near the Duwamish Diagonal outfall as a result of stormwater overflows. The model assumes that all processes that affect sediment concentrations do not change over time. For the Diagonal area, water currents, depths, and salinity are tidally affected, and discharges vary in magnitude and duration.

Review of the equation,

$$c(t) = \left(\frac{m}{m+kS}\right)c_i\left[1-\exp\left(\frac{-(m+kS)}{S}\right)t\right] + c_o \exp\left(\frac{-(m+kS)}{S}\right)t$$

where:
m = mass accumulation rate $mg/m^2/s$
k = chemical decay rate + sediment diffusion (1/s)
S = sediment solids concentration per sediment depth (mg/m^2)
t = time (s)
c_i = sorbed chemical concentration falling into sediment bed (ug/kg)
c_o = initial sorbed sediment chemical concentration (ug/kg)

The mass accumulation rate (m) determines how fast chemical concentrations will build-up in the sediments. The part of SEDCAM that models chemical accumulation in the sediment bed is,

$$c(t) = \left(\frac{m}{m+kS}\right)c_i\left[1-\exp\left(\frac{-(m+kS)}{S}\right)t\right]$$

if there is no chemical decay, then k=0 and the accumulation equation becomes,

$$c(t) = c_i\left[1-\exp\left(-\frac{m}{S}\right)t\right]$$

c_i is the concentration of sorbed chemical falling into the sediments and remains constant over time. The exponential term approaches zero as t (time) increases. This means that the sorbed sediment chemical concentrations will approach c_i , the steady state sorbed sediment chemical concentration, $c(\infty)=c_i$. The incoming chemical concentration c_i includes both the contaminated suspended solids and the clean suspended solids. C_i determines the ultimate sediment chemical concentration and m determines how fast the ultimate sediment concentration will be reached.

The second half of the SEDCAM equation,

$$c(t) = c_o \exp\left(\frac{-(m + kS)}{S}\right)t$$

determines the rate at which existing sediment chemical concentration decays over time. The decay process includes mixing of the incoming suspended solids with the sediment solids (m), and chemical decay (k). As time approaches infinity, the exponential term approaches zero. If the chemical decay (k=0) is zero, then the equation takes the form,

$$c(t) = c_o \exp\left(\frac{-(m)}{S}\right)t$$

This shows that the existing sediment chemical concentration decay is dependent upon the rate of suspended solids falling into the sediments. Implicitly implied in this equation, is that m represents the combined effect of clean and contaminated suspended solids mixing with the existing contaminated sediment.

The above form of SEDCAM/METSED simulates average conditions over long periods of time (months to years). However, SEDCAM/METSED can be used to simulate smaller time intervals if certain conditions prevail, these conditions are discussed at the end of this chapter.

Estimation of Model Parameters

Mass Accumulation Term

The mass accumulation term in SEDCAM is defined as:

$m = V_n * C_{tss}$

where:

V_n is the net suspended solids settling rate (m/s)
C_{tss} is the suspended solids concentration (g/m^3)

Estimates for the settling velocity and concentration terms were obtained from Metro's Draft Water Quality Assessment (WQA) report (1994) and from the Corps of Engineers Duwamish River Navigation Improvement Study (1981). Modeling results of the WQA report provided suspended solids concentrations and settling velocities. Initial settling velocities were based upon observations reported by the Corps of Engrs study (1981) that estimated the mass of suspended solids settling between the Duwamish head of navigation and the 16th Ave bridge. Estimates of the suspended solids settling rate from the WQA study and the Corps of Engineers study,

$V_n = 7.82 \times 10^{-5}$ (m/s), WQA study

$V_n = 16.9 \times 10^{-5}$ (m/s), COE study

Using the WQA settling velocity the suspended solids concentration near the Duwamish/Diagonal area was estimated at,

$C_{tss} = 3.72$ (mg/l)

Therefore, the ambient mass accumulation rate is estimated as,

$m = 0.92$ (g/cm^2/yr)

First Order Organic Chemical Decay Rate

Organic chemical decay rates were obtained from EPA's Processes, Coefficients, and Models for Simulating Toxic Organics and Heavy Metals in Surface Waters (1987) manual. The manual does not state whether the rates were for freshwater or marine environments . The average decay rates for the Phthalates are given in Table I.

TABLE I

ORGANIC CHEMICAL DECAY RATES

Chemical of Concern	Decay Rate (1/yr)
Bis(2-ethylhexyl) Phthalate	1.069
Butyl Benzyl Phthalate	126

Chemical Partitioning Parameters

Chemical partitioning of organic compounds to suspended solids is dependent on the fraction of organic content in the solid. The organic fraction was estimated from Duwamish sediment field samples, the upper 95% value (8.9%) was used to compute the organic partition value given by the equation,

$$P = f_{oc} K_{ow}$$

where:
P = Partitioning coefficient (l / kg)
f_{oc} = Fraction of organic content in the solids
K_{ow} = Log octonol partitioning coefficient (l / kg)

Partition coefficient values for both organics and metals are given in Table II, values were obtained from the Syracuse Research Corp (1994).

TABLE II

CHEMICAL PARTITION COEFFICIENTS

Chemical of Concern	Partition Coefficient (l/kg)
Bis(2-ethylhexyl) Phthalate	4700
Butyl Benzyl Phthalate	2966
Arsenic	512000
Cadmium	262200
Chromium	512000
Copper	7337000
Lead	988200
Mercury	408
Nickel	500000
Silver	156000
Zinc	344650

Sediment Diffusion Effects

SEDCAM does not explicitly simulate the diffusion of a dissolved chemical across the sediment water interface, rather it approximates diffusion through a decay term. Diffusion can become significant when suspended solids settling into the sediments becomes very small. Because documentation concerning the use of diffusive decay was not available, it was not included in the modeling.

Chemical Discharge Concentrations

End of pipe discharge concentrations for the chemicals of concern were obtained from the WQA report (1994). The concentrations in the WQA report were gathered from Metro and City of Seattle CSO and stormwater studies. Combined sewer overflow concentrations were used and are given in Table III.

Mixing of the CSO in the Duwamish Estuary

SEDCAM assumes the discharge is completely mixed over the water volume in question. The user has the option of defining the volume over which dilution occurs, i.e. the user could design the model such that mixing occurs over one half the river width (half the river flow mixes with the CSO). Or, it could be specified that mixing occurs over the full river width (all the river flow mixes with the CSO). Specification of the river mixing width implicitly determines the volume of river water that dilutes the CSO.

Dilution is computed as the inverse fraction of discharge flow to total river cross section flow. As an example, if the discharge flow is Q_d , and the total river discharge is Q_R , and the river area affected by the discharge is A_1, see Figure 1. For simplicity, the area terms are replaced by their effective widths w_1 and w_T, the dilution (S) was computed as,

$$S = \left(\frac{Q_d}{Q_d + \frac{w_1}{w_T} Q_R} \right)^{-1}$$

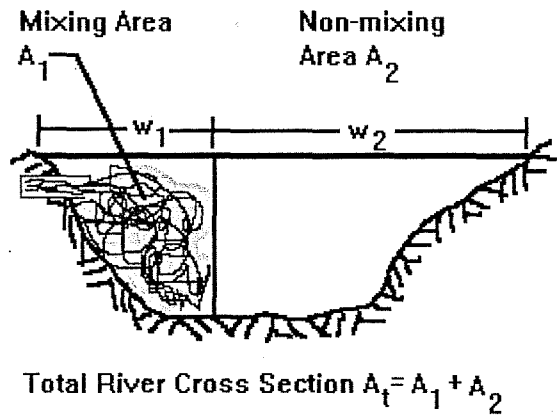

Figure 1. River section (A_1) effected by CSO discharge.

TABLE III

IN PIPE DISCHARGE CHEMICAL CONCENTRATIONS

Chemical of Concern	Chemical Concentration in Pipe (ug/l)
Bis(2-ethylhexyl) Phthalate	9.45
Butyl Benzyl Phthalate	2.2
Arsenic	9.52
Cadmium	1.46
Chromium	13.5
Copper	43.6
Lead	65.9
Mercury	.31
Nickel	12.3
Silver	2.74
Zinc	179

Recontamination Rates and Concentrations Using Annual Flows

The annual discharge volume for the Diagonal (9.54×10^7 ,cft) was computed by Seattle Drainage and Wastewater Utility, and annual Green River discharge volume (4.825×10^{10}, cft) was estimated from the USGS Tukwila gaging station flow records.

The volume of water over which the CSO is diluted is dependent upon how much of the river width the CSO plume mixes over. To understand the difference the mixing width has upon recontamination rates and concentrations, three mixing widths were studied: 1) assumed the discharge mixed over the entire river width(1000 ft),2) the approximate width of contamination(175 ft) 3) assumed that momentum forces control the mixing width (more representative of what actually occurs in the near vicinity of the outfall).

The distance that the CSO plume will extend into the river (length L_R) depends on the river velocity and the momentum of the CSO plume. The CSO plume will start to flow in the downstream direction L_R units from the bank given by the equation,

$$L_R = M^{1/2} / U$$

where:
L_R = Crossflow length scale (L)
M = CSO discharge momentum (L^2/T^2)
U = Mean river velocity (L/T)

To compute the momentum of the CSO discharge the CSO hydrograph is needed to compute the velocity. Instantaneous Diagonal CSO flows were estimated from a Michigan St CSO hydrograph, multiplying the Michigan St hydrograph by the ratio of the annual Diagonal discharge over annual Michigan St discharge. Conversion of the Michigan hydrograph resulted in an estimated Diagonal discharge of 8 (cfs). The mean river velocity near the Diagonal CSO was estimated at 0.23 (ft/s). Computing the resulting crossflow length scale,

L_R = 16.6 ft (5 m)

Estimating the discharge area to total area (Figure 1) as a ratio of widths, the three dilution numbers are as given in Table IV.

TABLE IV

ESTIMATED DILUTION FACTORS FOR
MIXING OF CSO INTO THE
DUWAMISH
CONSTANT DISCHARGE

Mixing Area (width, ft)	Dilution
1000	507
175	90
16.6	9.5

The fraction of chemical partitioning to the suspended solid is computed as,

$$F = \frac{Pc_{ss}}{1 + Pc_{ss}}$$

where:
F is the fraction of chemical sorbed to the suspended solid
P is partitioning coefficient (l / kg)
c_{ss} is suspended solids concentration (ug / l)

Suspended solids concentrations for each mixing area were computed by,

$$c_{ss} = \frac{CSO_{ss}}{S}$$

where:
CSO_{ss} is the suspended solids concentration in the CSO effluent (ug / l)
S is the dilution

The sorbed chemical concentration falling into the sediments is given by,

$$c_i = Fc_T$$

where:
F is the fraction sorbed to the suspended solids
C_T is the total chemical concentration after dilution (ug / l)

Total suspended solids concentrations from the CSO significantly influenced the suspended solids concentration when the mixing width was 16.6 ft. This effects both the mass accumulation rate and the sorbed chemical concentrations. Effects of the three mixing widths on SEDCAM/METSED parameters are summarized in Table V. Sorbed chemical concentrations for the three mixing widths are significantly different.

TABLE V SEDCAM/METSED PARAMETER VALUES FOR MIXING WIDTHS OF 1000 FT, 175 ft, 16.6 FT

Constant Loading Case

			16.6 ft Mixing Width				175 ft Mixing Width				1000 ft Mixing Width				
Compound	CSO Conc. (ug/l)	SQS (ug/kg)	Dilution	TSS (mg/l)	Mixed Sed. Conc (ug/kg)	Cmix/ Csqs	Dilution	TSS (mg/l)	Mixed Sed. Conc (ug/kg)	Cmix/ Csqs	Dilution	TSS (mg/l)	Mixed Sed. Conc (ug/kg)	Cmix/ Csqs	Width (ft) Cmix=Csqs
Arsenic	9.52	57000	9.4	16.73	54219	.95	90	5.09	15109	.27	507	3.96	3176	.06	15
Cadmium	1.46	5100			7562	1.48			1833	.36			371	.07	40
Chromium	13.47	260000			76716	.30			21378	.08			4494	.02	<1
Copper	43.6	390000			275057	.71			93271	.24			20997	.05	<1
Lead	65.87	450000			395046	.88			120678	.27			26136	.06	10
Mercury	.31	410			13	.03			1	0			0	0	<1
Nickel	12.34				70104				19455				4085		
Silver	2.74	6100			12600	2.07			2663	.44			521	.09	60
Zinc	178.8	410000			969139	2.36			250083	.61			51411	.13	90
Bis(2-ethyl)	9.45	47000			49241	1.05			5434	.12			961	.02	18
Butyl	2.2	4900			7434	1.52			806	.16			142	.03	26

If the parameters change over time, but it is assumed that the changes can be represented by a discrete step function, where the changes are constant over each time step. Then a series of SEDCAM models can be used with each series having a different set of parameter values for each time step. Initial chemical concentrations are determined from previous SEDCAM results, Figure 2 shows a flow chart of the temporal progression of the computations.

A CSO does not discharge continuously into a water body, discharges are intermittent. When the time dependent loading scenario (SEDCAM series) was compared to the time averaged scenario, final sediment concentrations for the time dependent

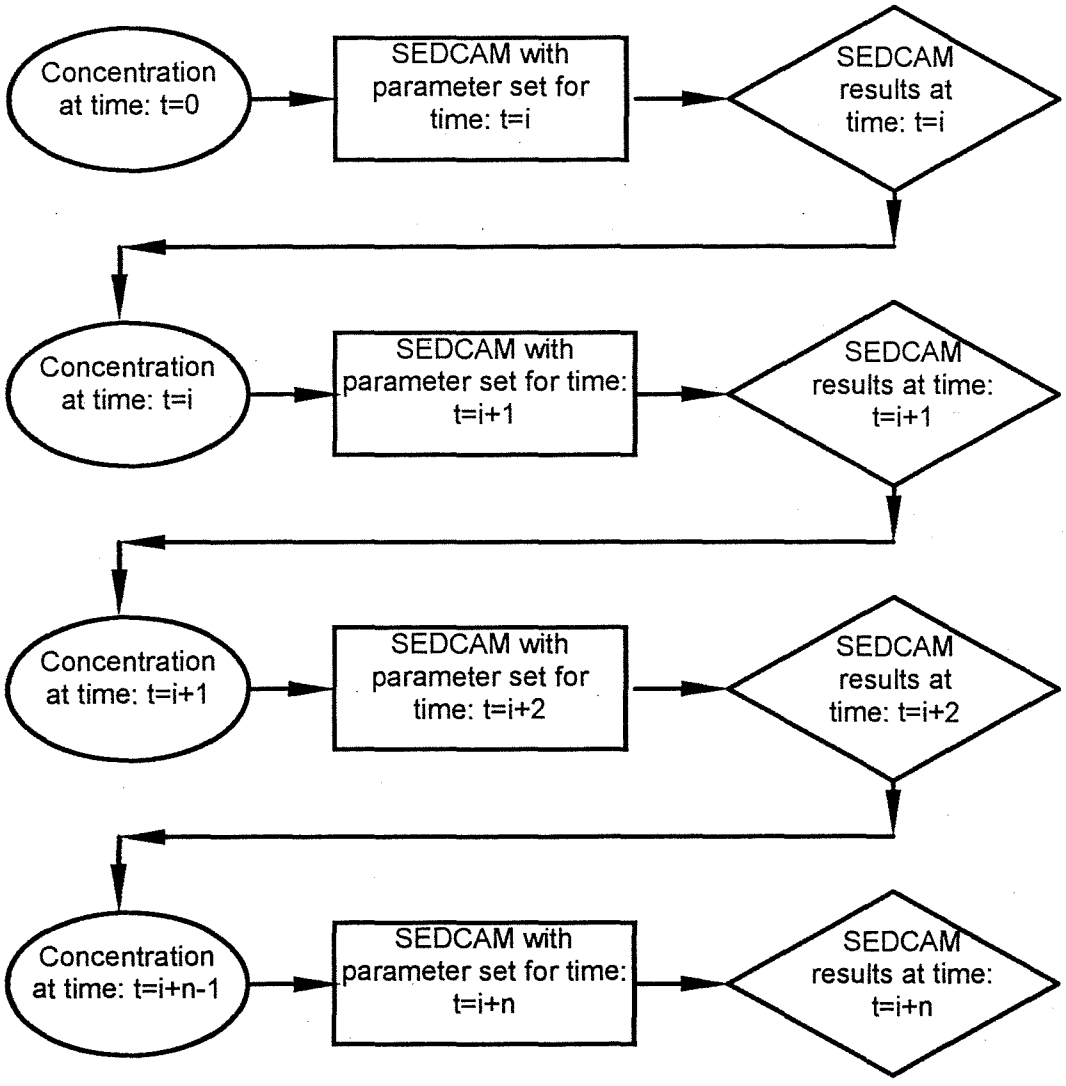

Figure 2. Temporal progression of SEDCAM computations using time varying parameters.

loading scenario were a factor of 3 to 4 greater than the time averaged concentrations. Testing of the SEDCAM model indicated that the mass accumulation rate into the sediment bed during a CSO is greater than the time averaged mass accumulation rate. And the mass accumulation rate when the CSO is not discharging is less than the time averaged. Non-discharging events result in less clean suspended solid mass mixing in with the sediments. Therefore, the apparent sediment chemical concentration decays at a slower rate than the time averaged rate. During the loading interval the contaminated suspended solid concentration mixing into the sediments is greater than the time averaged. The combined effect of smaller mass accumulation rates during non-discharge periods and greater rates during peak loads results in higher sediment concentrations than would occur using a time averaged mass accumulation rate.

What can also happen is that when the CSO is not discharging, the series approach allows clean solids to mix with the contaminated sediments. Effectively cleaning or diluting the sediments. If the time between discharges is significant then it is possible that natural remediation would clean the sediments to ambient conditions before the next CSO event. Generally the series approach is much more realistic than the annual loading approach.

A one year hydrograph for the Diagonal CSO was synthesized from a Michigan St CSO hydrograph, segmenting the flows into weekly time intervals. As well, weekly flows for the Green River were computed from daily flow records at the Auburn gagging station, both hydrographs are shown in Figure 3. The CSO and the river hydrographs were used to compute total suspended solids concentrations, sorbed chemical concentrations, and mass accumulation rates in the SEDCAM model resulting in 52

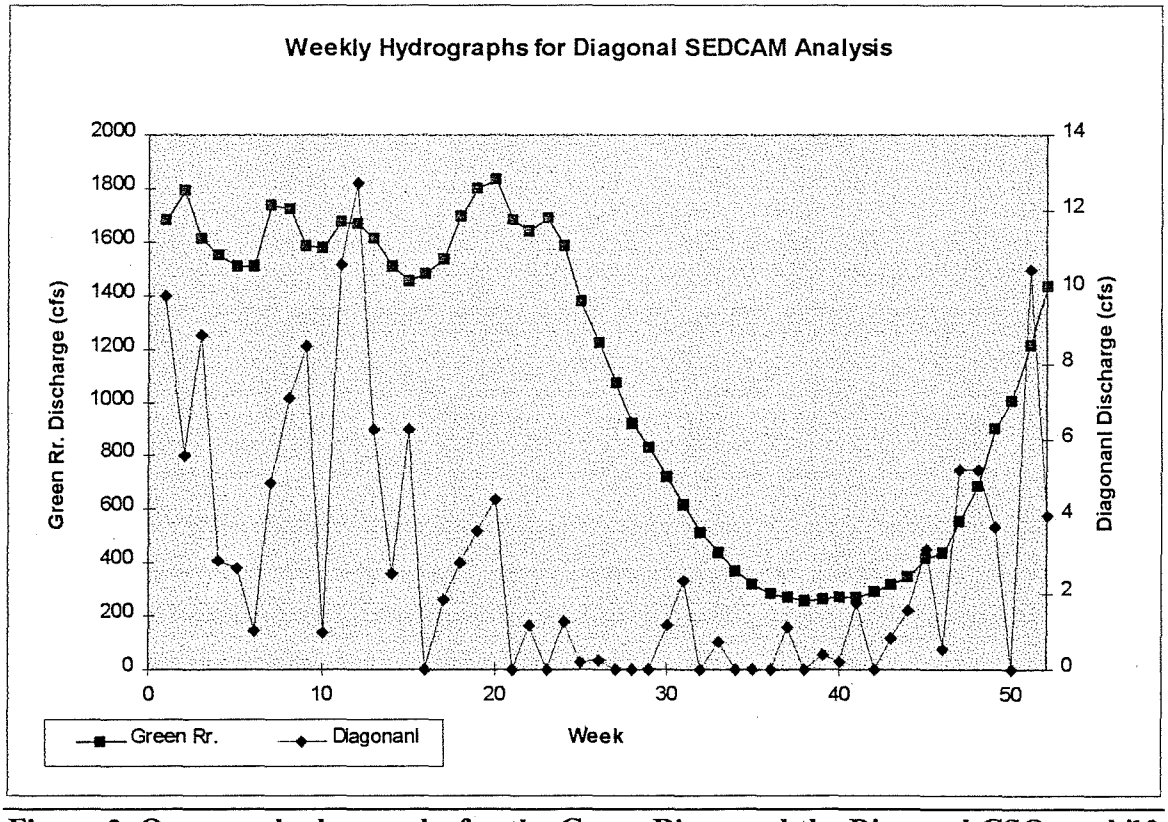

Figure 3. One year hydrographs for the Green River and the Diagonal CSO used in the SEDCAM series analysis.

SEDCAM equations (All other model parameters remained constant). The 52 week hydrographs were repeated until chemical concentrations in the sediments approached a steady-state value. As an example, sediment response to a discharge of Butylbenzene from the Diagonal CSO across a 16.6 ft width of the Duwamish using SEDCAM in series is shown in Figure 4. The 52 week hydrograph was repeated 21 times (21 years) varying the suspended solids concentration, sorbed chemical concentration, and mass accumulation rate based upon the weekly discharge rates of the Green River and the Diagonal CSO. The SEDCAM series analysis was used to estimate toxicant concentrations in the sediments and the time to reach steady-state concentrations.

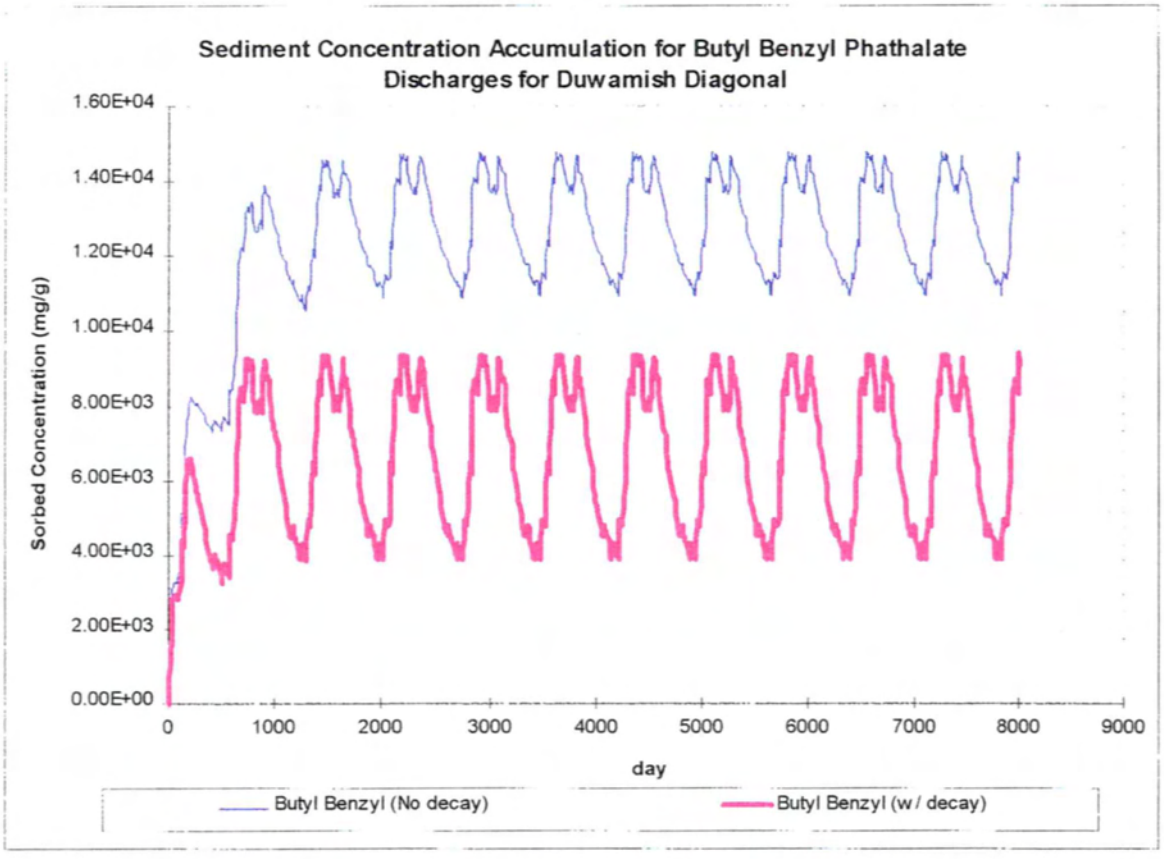

Figure 4. Sediment chemical response from a discharge of Butylbenzyl phthalate at the Diagonal CSO varying the suspended solids concentration and mass accumulation rate base on Green River and Diagonal discharge rates.

Summary:

The output of this model is summarized in Tables V and VI These tables includes the long term equilibrium sediment concentration for the listed toxicants for the constant loading case(Table V) and the variable loading case (Table VI) and a comparison of these concentrations to WA sediment quality standards. The conclusion from these tables are that none of the toxicants will exceed the WA sediment quality standards within ten years of the time of cleanup. In the attached appendix the Stormwater Toxicant Concentration table summarizes the results of recent stormwater sampling and also includes stormwater data compiled by Brown and Caldwell in 1988. Also included in the first column are the discharge concentrations that were used for this modeling effort, they were derived from earlier studies and had been thought to be conservative estimates of stormwater toxicant concentrations. As can be seen from the modeling values and the sampling data, the values used for the modeling effort were in excess of the measured stormwater values, therefore the equilibrium sediment toxicant levels derived from the modeling effort are conservative estimates of the expected sediment concentrations. The data presented here assumes that the dilution of the stormwater discharge takes place over three river widths, 16.6 feet, which is the width that the typical plume would extend solely due to discharge momentum effects, 175 feet, which approximates the width of contamination, and 1000 feet which represent the total width of the river. The last column of Tables V and VI also calculate the 'apparent' mixing river width that would be mathematically required for the long term sediment concentration to equal the sediment quality standards after reaching equilibrium. These 'apparent' river widths are all less than the 175 foot width of actual contamination as shown by sampling, a further indication that recontamination will not exceed the sediment quality standards within ten years. The toxicants that approach closest to the sediment standards after 10 years are zinc, silver, butyl benzyl phthalate and bis(2-ethylhexyl)phthalate.

Table VI

Variable Load Compound	CSO Conc. (ug/l)	SQS (ug/kg)	16.6 ft Mixing Width				175 ft Mixing Width				1000 ft Mixing Width				Width (ft) Cmix=Csqs
			Dilution	TSS (mg/l)	Mixed Sed. Conc (ug/kg)	Cmix/ Csqs	Dilution	TSS (mg/l)	Mixed Sed. Conc (ug/kg)	Cmix/ Csqs	Dilution	TSS (mg/l	Mixed Sed. Conc (ug/kg)	Cmix/ Csqs	
Arsenic	9.52	57000	7.34	20.38	57134	1.0	67	5.52	19287	.34	382	4.04	4123	.07	17
Cadmium	1.46	5100			8216	1.61			2452	.48			488	.10	60
Chromium	13.47	260000			80840	.31			27289	.10			5833	.02	<1
Copper	43.6	390000			280465	.72			111016	.28			26537	.07	<1
Lead	65.87	450000			409407	.91			149157	.33			33535	.07	8
Mercury	.31	410			24	.06			2	.01			0	0	<1
Nickel	12.34				73933				24870				5305		
Silver	2.74	6100			14214	2.33			3723	.61			695	.11	95
Zinc	178.8	410000			1037663	2.53			327709	.80			67308	.16	130
Bis(2-ethyl)	9.45	47000			83670	1.78			9059	.19			1338	.03	35
Butyl	2.2	4900			12940	2.64			1348	.28			198	.04	52

Corps of Engineers, (1981). Duwamish Waterways Navigation Improvement Study: Analysis of Impacts on Water Quality and Salt Wedge Characteristics.

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EPA, (1987). Processes, Coefficients, and Models for Simulating Toxic Organics and Heavy Metals in Surface Waters. EPA/600/3-87/015

Jacobs, L.A., R.C. Barrick and T.C.Ginn. 1988. Application of a Mathematical Model (SEDCAM) to evaluate the effects of source control on sediment contamination in Commencement Bay. In: Proc of the First Annual Meeting on Puget Sound Research, 18-19 March 1988, Seattle, WA.

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Syracuse Research Corporation, 1994. Dr. Philip H. Howard, (315) 426-3200. Syracuse N.Y.

Duwamish/Diagonal Modeling Report
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Constant Discharge Results, Table and Chart
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Variable Discharge Results, Table and Chart
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Variable Discharge Results, Table and Chart
- Benzyl Butyl Phthalate, 16 ft mixing
- Benzyl Butyl Phthalate, 175 ft mixing
- Benzyl Butyl Phthalate, 1000 ft mixing

Variable Discharge Results, Table and Chart
- Bis(2-ethylhexyl) Phthalate, 16 ft mixing
- Bis(2-ethylhexyl) Phthalate, 175 ft mixing
- Bis(2-ethylhexyl) Phthalate, 1000 ft mixing

Modeled Hydrographs Duwamish Flow and Green River

Week	Norfolk (cfs)	Green Rr. (cfs)
1	9.76	1684.46
2	5.60	1790.30
3	8.77	1611.85
4	2.87	1549.98
5	2.68	1507.20
6	1.00	1509.26
7	4.89	1736.23
8	7.12	1725.20
9	8.46	1583.59
10	0.99	1574.77
11	10.59	1675.88
12	12.74	1664.57
13	6.28	1611.79
14	2.50	1508.61
15	6.29	1451.68
16	0.00	1484.26
17	1.85	1537.30
18	2.81	1696.20
19	3.64	1798.49
20	4.44	1836.92
21	0.00	1682.92
22	1.14	1638.95
23	0.00	1690.11
24	1.27	1585.05
25	0.17	1380.42
26	0.24	1224.47
27	0.00	1074.79
28	0.00	919.73
29	0.00	833.08
30	1.16	717.51
31	2.30	616.73
32	0.00	512.84
33	0.73	437.60
34	0.00	367.50
35	0.00	315.76
36	0.00	285.32
37	1.11	269.66
38	0.00	254.88
39	0.39	264.58
40	0.17	270.97
41	1.75	268.20
42	0.00	289.18
43	0.84	315.11
44	1.56	342.63
45	3.16	413.10
46	0.55	436.26
47	5.25	555.03
48	5.22	683.22
49	3.75	899.83
50	0.00	1006.78
51	10.46	1211.80
52	4.03	1435.82

Stormwater vs model

					STORMWATER SAMPLES									
		L6478-1	L6744-1	L6714-1	L6744-2	L7049-1	L7074-1	L7133-1	L7204-1	L7300-1	L7300-2		B&C*	B&C*
	model input	9-Jul	16-Aug	11-Aug	16-Aug	27-Sep	2-Oct	10-Oct	20-Oct	8-Nov	8-Nov	Sample	Comm/Ind /Hghwy Avg	All uses avg
	ug/l	hinds	hinds	horton	horton	horton	horton	horton	horton	hinds	horton	avg	1974-81	1986-88
Arsenic	9.52	3.05	3.11	1.6	3.4	3.71	3.37	1.9	2.24	2.83	2.26	2.75		
Cadmium	1.46	0.1	0.46	0.49	0.61	0.8	0.78	0.33	0.4	0.9	0.61	0.55	2.3	0.8
Chromium	13.47	22	3.3	5.9	4.49	5.75	6.01	2.13	2.2	17	3.5	7.23		6.2
Copper	43.6	119	41.1	33.8	34.3	54.2	31.8	20.7	20.7	75.4	39	47.00	99	31
Lead	65.87	63.4	21.7	8.51	44.1	68.1	61.3	18.3	30.2	42.5	34.8	39.29	377	57
Mercury	0.31	0.1	0.1	0.1	0.32	0.1	0.1	0.1	0.1	0.1	0.1	0.12		
Nickel	12.34	34	6.28	12.7	6.89	7.82	6.5	2.96	4.37	26.1	4.15	11.18		
Silver	2.74					0	0	0	0			0.00		
Zinc	178.8	308	79.2	215	104	135	130	49.8	94.5	255	81.4	145.19	259	117
Butyl	2.2	0.79	0.29	0.29	0.92	0.84	0.29	0.29	0.987	0.29	0.9	0.59		
Bis(2-ethyl)	9.45	6.07	10.1	7	7.09	6.75	5.17	14.7	0.29	3.48	8.11	7.15		
xx.x	Shaded cell reported as <MDL, assigned 0.5xMDL for average calculations.													
B&C*	Analysis of Stormwater Monitoring Data, 1989, Steve Merrill													

Variable input

Duwamish Section

Width =	1000
TSS =	3.72

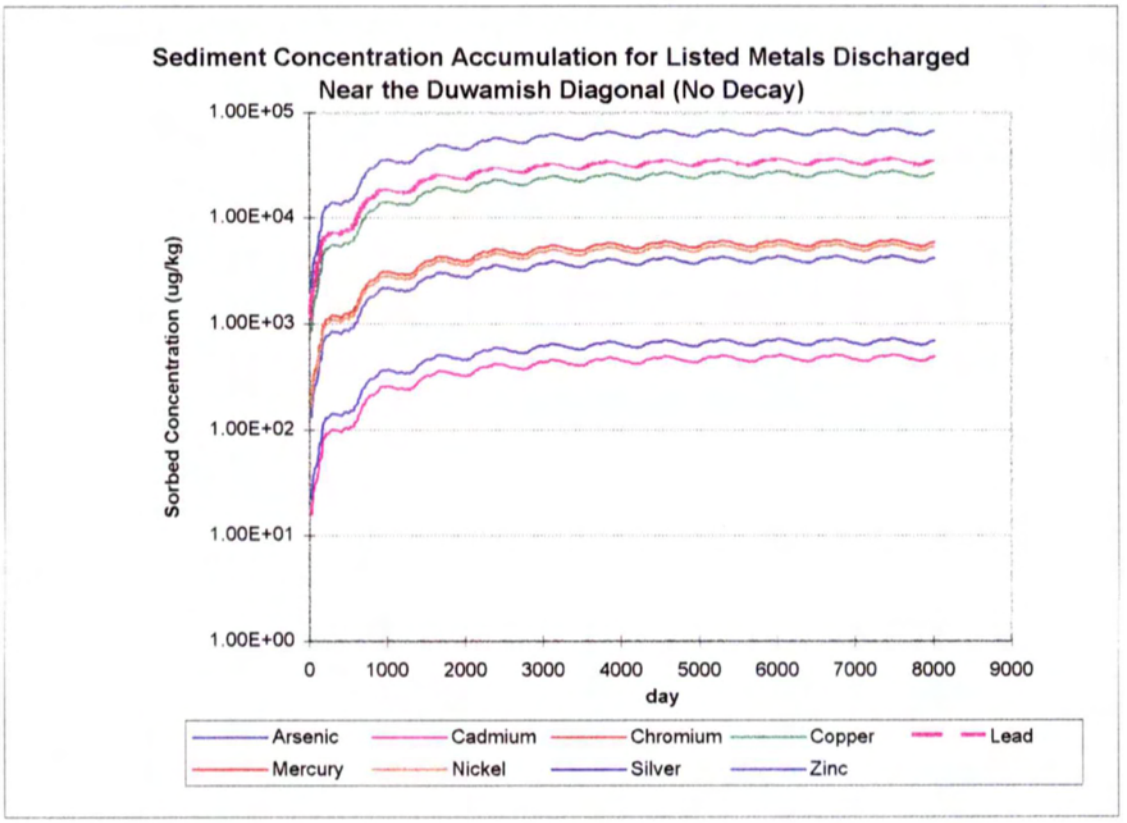
Mixing Section

Width =	1000
TSS =	126
(g/sqcm/yr)	0.99

Time to reach steady-state for a decay (1/yr)

k = 0	8.43 yrs
k = .0843	6.44 yrs

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Csqs SQS (ug/kg)	Cm/Csqs	Fitted width where: Cm = Csqs (ft)
Arsenic	512,000	4.04	382.89	9.52	4,123	57,000	0.07	18
Cadmium	262,200	4.04	382.89	1.46	488	5,100	0.10	55
Chromium	512,000	4.04	382.89	13.47	5,833	260,000	0.02	1
Copper	7,337,000	4.04	382.89	43.6	26,537	390,000	0.07	1
Lead	988,200	4.04	382.89	65.87	33,535	450,000	0.07	10
Mercury	408	4.04	382.89	0.31	0	410	0.00	1
Nickel	500,000	4.04	382.89	12.34	5,305			
Silver	156,000	4.04	382.89	2.74	695	6,100	0.11	95
Zinc	344,650	4.04	382.89	178.8	67,308	410,000	0.16	130



Variable input

Duwamish Section

Width =	1000
TSS =	3.72

Mixing Section

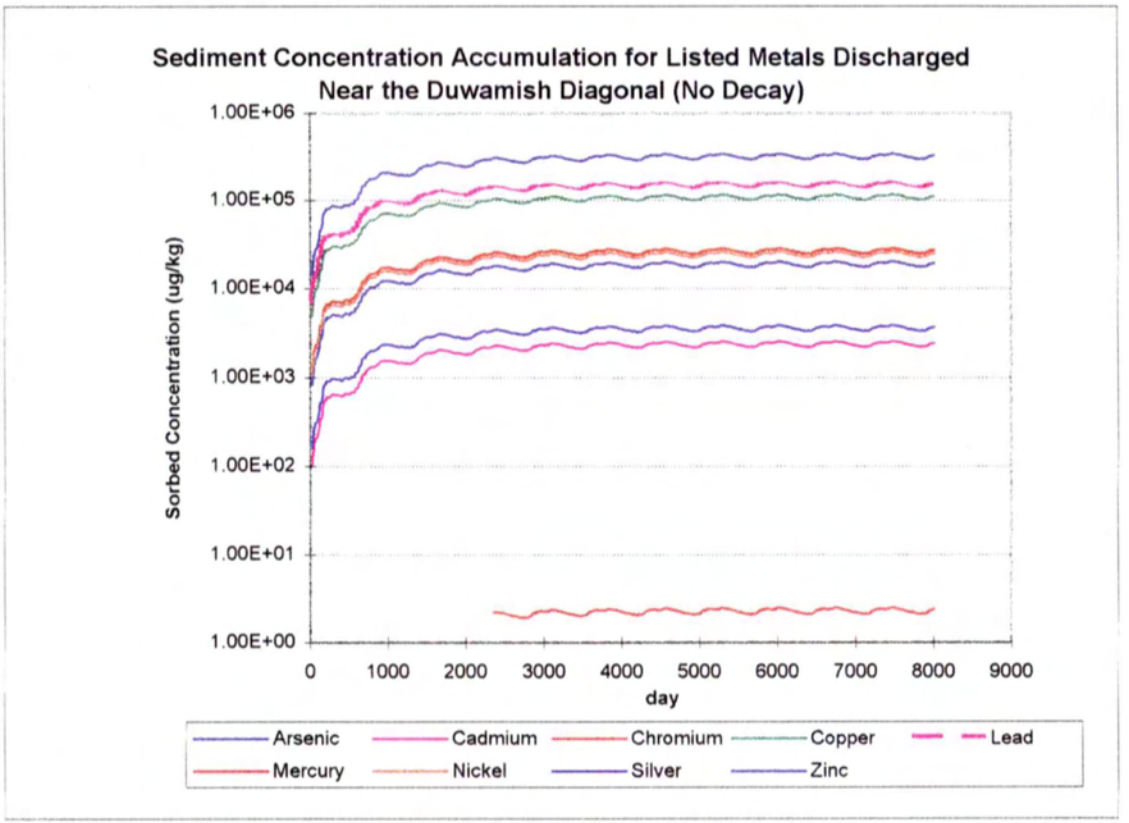
Width =	175
TSS =	126
(g/sqcm/yr)	1.35

Time to reach steady-state for a decay (1/yr)

k = 0 4.88 yrs

k = .0843 4.14 yrs

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Csqs SQS (ug/kg)	Cm/Csqs	Fitted width where: Cm = Csqs (ft)
Arsenic	512,000	5.52	67.83	9.52	19,287	57,000	0.34	18
Cadmium	262,200	5.52	67.83	1.46	2,452	5,100	0.48	55
Chromium	512,000	5.52	67.83	13.47	27,289	260,000	0.10	1
Copper	7,337,000	5.52	67.83	43.6	111,016	390,000	0.28	1
Lead	988,200	5.52	67.83	65.87	149,157	450,000	0.33	10
Mercury	408	5.52	67.83	0.31	2	410	0.01	1
Nickel	500,000	5.52	67.83	12.34	24,870			
Silver	156,000	5.52	67.83	2.74	3,723	6,100	0.61	95
Zinc	344,650	5.52	67.83	178.8	327,709	410,000	0.80	130



Variable input

Duwamish Section

Width =	1000
TSS =	3.72

Mixing Section

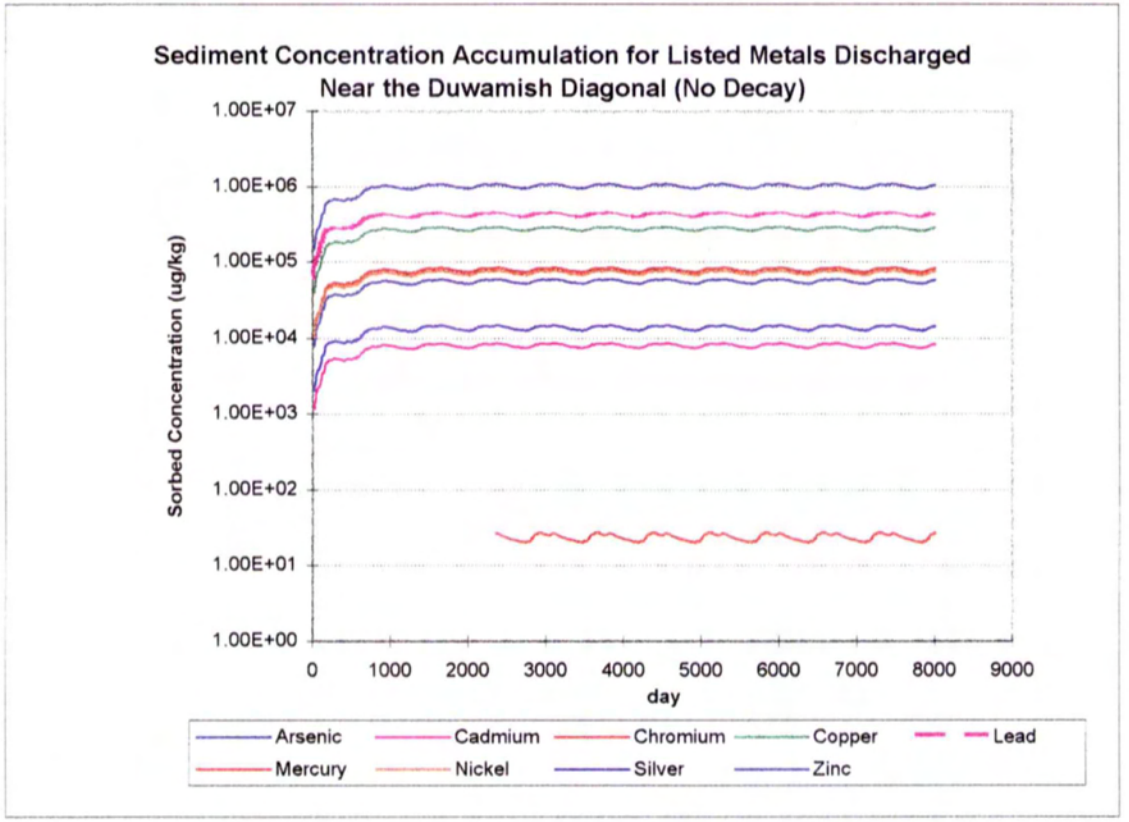
Width =	16.6
TSS =	126
(g/sqcm/yr)	4.50

Time to reach steady-state for a decay (1/yr)

k = 0 1.05 yrs

k = .0843 1.02 yrs

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Csqs SQS (ug/kg)	Cm/Csqs	Fitted width where: Cm = Csqs (ft)
Arsenic	512,000	20.38	7.34	9.52	57,134	57,000	1.00	18
Cadmium	262,200	20.38	7.34	1.46	8,216	5,100	1.61	55
Chromium	512,000	20.38	7.34	13.47	80,840	260,000	0.31	1
Copper	7,337,000	20.38	7.34	43.6	280,465	390,000	0.72	1
Lead	988,200	20.38	7.34	65.87	409,407	450,000	0.91	10
Mercury	408	20.38	7.34	0.31	24	410	0.06	1
Nickel	500,000	20.38	7.34	12.34	73,933			
Silver	156,000	20.38	7.34	2.74	14,214	6,100	2.33	95
Zinc	344,650	20.38	7.34	178.8	1,037,663	410,000	2.53	130



DIAG2'.XLS

Time to reach steady-state for a decay (1/yr)

k=0 2.23 yrs

k=1.0 1.13 yrs

Duwamish Section

Width= 1000

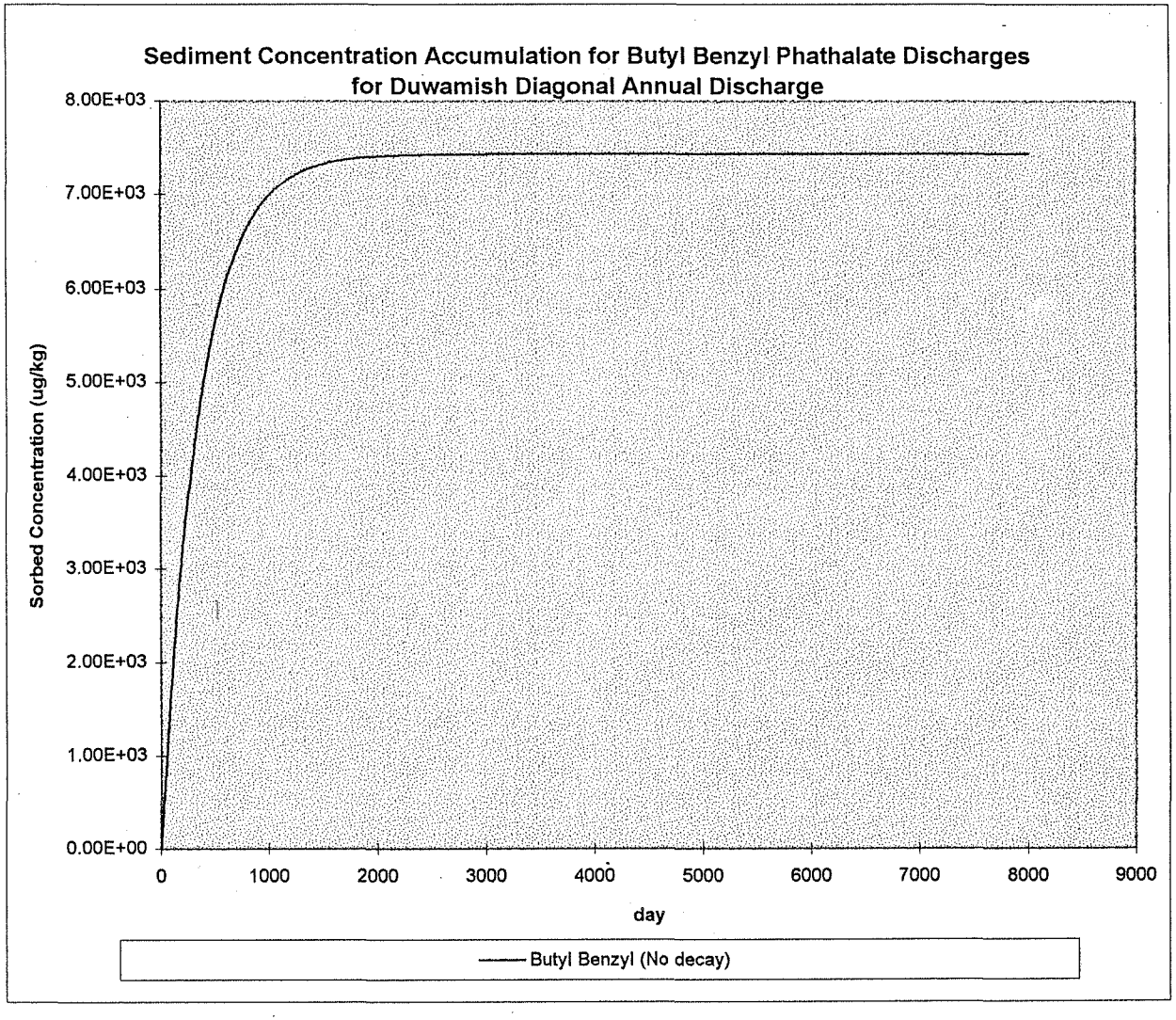
TSS= 3.72

Mixing Section

Width= 16.6

TSS= 126

Chemical	Annual Conditions Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Organic Carbon Mixed (ug/kg)	SQS (ug/kg)	Cm/Csqs	Fitted widt where: Cm = Csq (ft)
Butyl	2,966	16.73	9.40	2.2	7,434	4,900	1.52	26



DIAG2'.XLS

Time to reach steady-state for a decay (1/yr)

k=0 7.33 yrs

k=1.0 1.75 yrs

Duwamish Section

Width= 1000

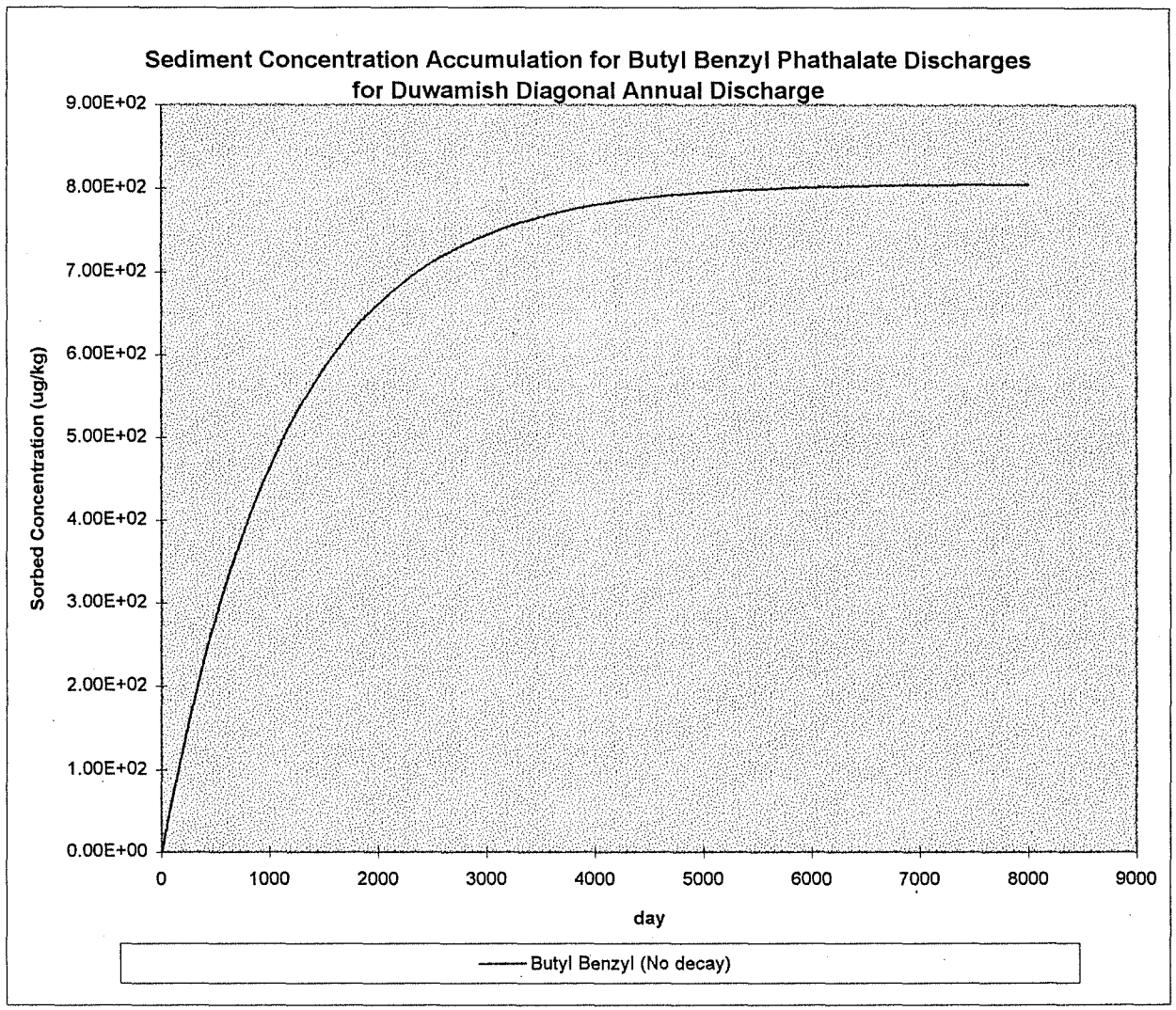
TSS= 3.72

Mixing Section

Width= 175

TSS= 126

Chemical	Annual Conditions Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Organic Carbon Mixed (ug/kg)	SQS (ug/kg)	Cm/Csqs	Fitted widt where: Cm = Csq (ft)
Butyl	2,966	5.09	89.51	2.2	806	4,900	0.16	26



DIAG2'.XLS

Time to reach steady-state for a decay (1/yr)

k=0 9.42 yrs.

k=1.0 1.85 yrs

Duwamish Section

Width= 1000

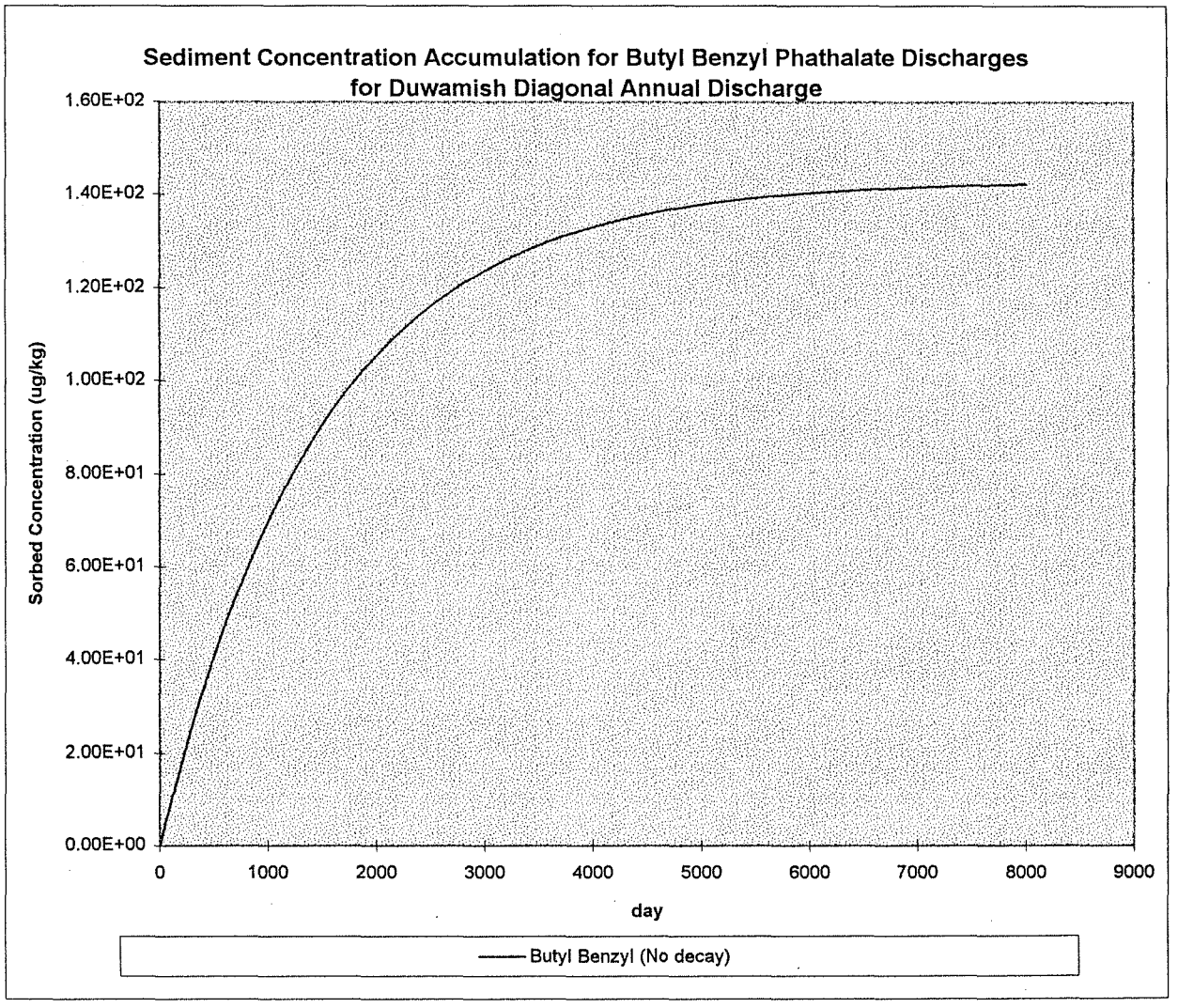
TSS= 3.72

Mixing Section

Width= 1000

TSS= 126

Chemical	Annual Conditions Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Organic Carbon Mixed (ug/kg)	SQS (ug/kg)	Cm/Csqs	Fitted widt where: Cm = Csq (ft)
Butyl	2,966	3.96	506.77	2.2	142	4,900	0.03	26

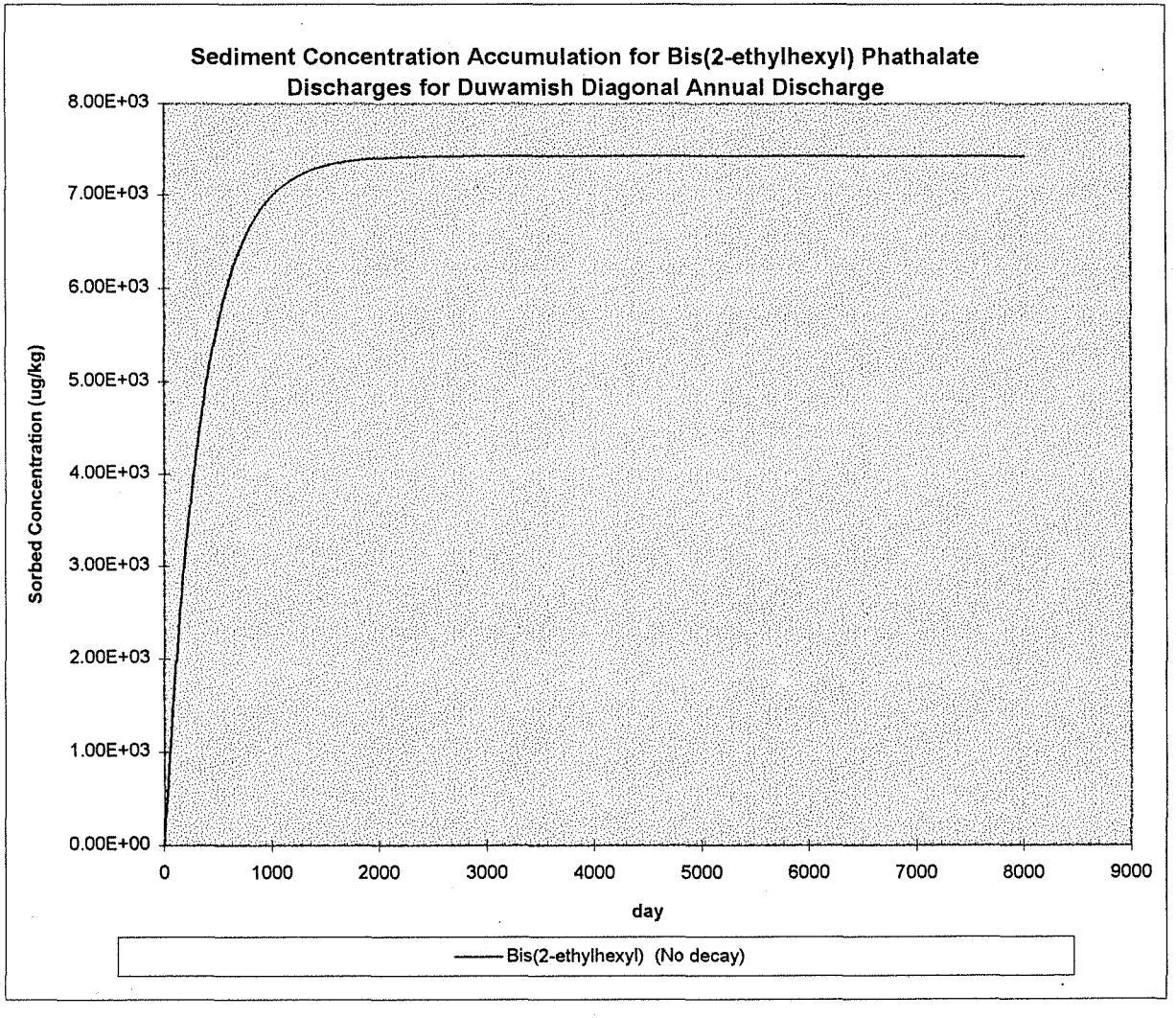


Time to reach steady-state for a decay (1/yr)

k = 0	2.23 yrs
k = 1.0	1.13 yrs

Duwamish Section
Width = 1000
TSS = 3.72
Mixing Section
Width = 16.6
TSS = 126

Chemical	Annual Conditions Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Organic Carbon Mixed (ug/kg)	SQS (ug/kg)	Cm/Csqs	Fitted widt where: $Cm = C_{sq}$ (ft)
Bis(2-ethyl	4,700	16.73	9.40	9.45	49,241	47,000	1.05	18



DIAG2'.XLS

Time to reach steady-state for a decay (1/yr)

k = 0 7.33 yrs

k = 1.0 1.75 yrs

Duwamish Section

Width = 1000

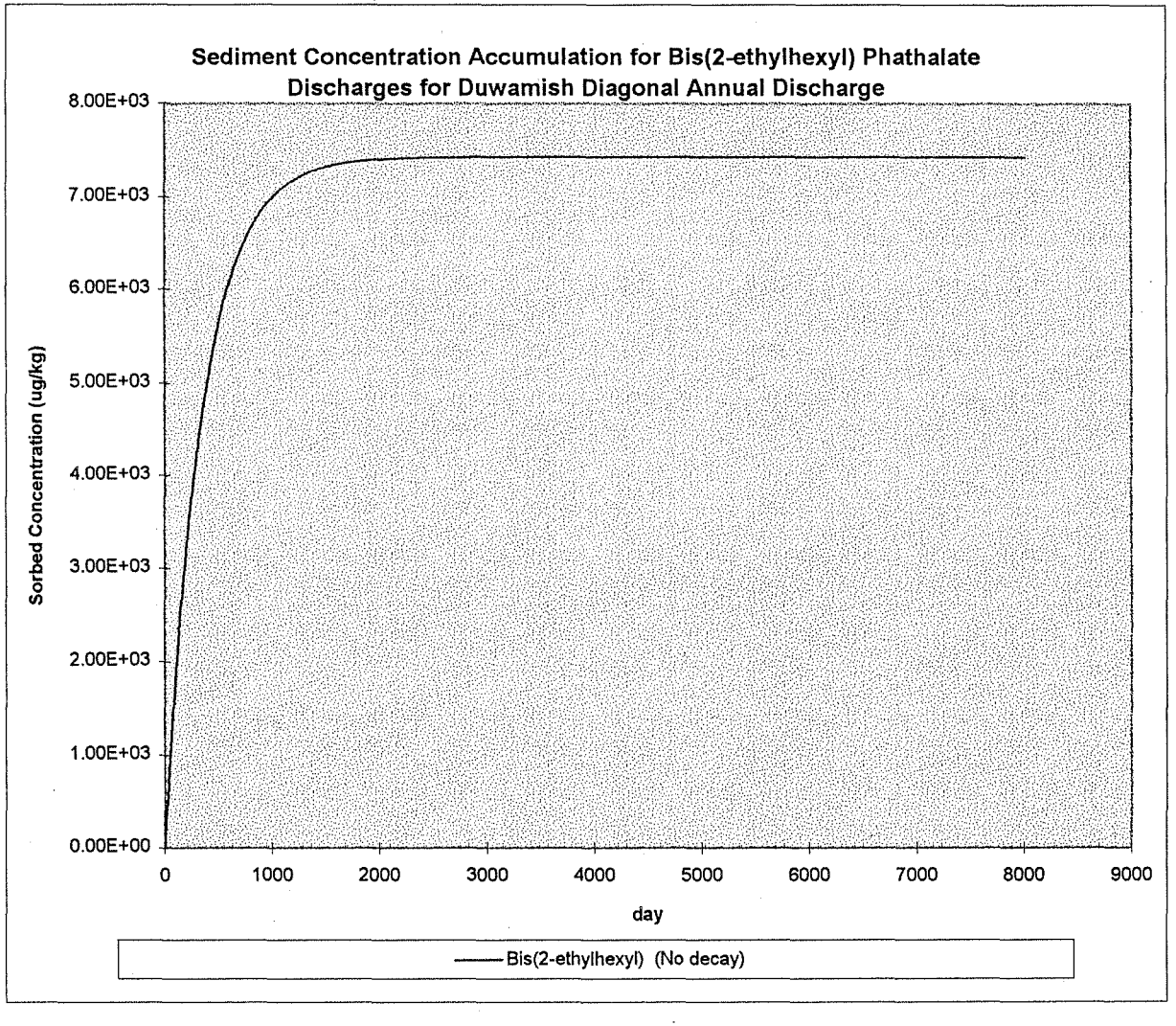
TSS = 3.72

Mixing Section

Width = 175

TSS = 126

Chemical	Annual Conditions Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Organic Carbon Mixed (ug/kg)	SQS (ug/kg)	Cm/Csqs	Fitted widt where: $Cm = C_{sq}$ (ft)
Bis(2-ethyl	4,700	5.09	89.51	9.45	5,437	47,000	0.12	18



DIAG2'.XLS

Time to reach steady-state for a decay (1/yr)

k = 0 9.42 yrs

k = 1.0 1.85 yrs

Duwamish Section

Width = 1000

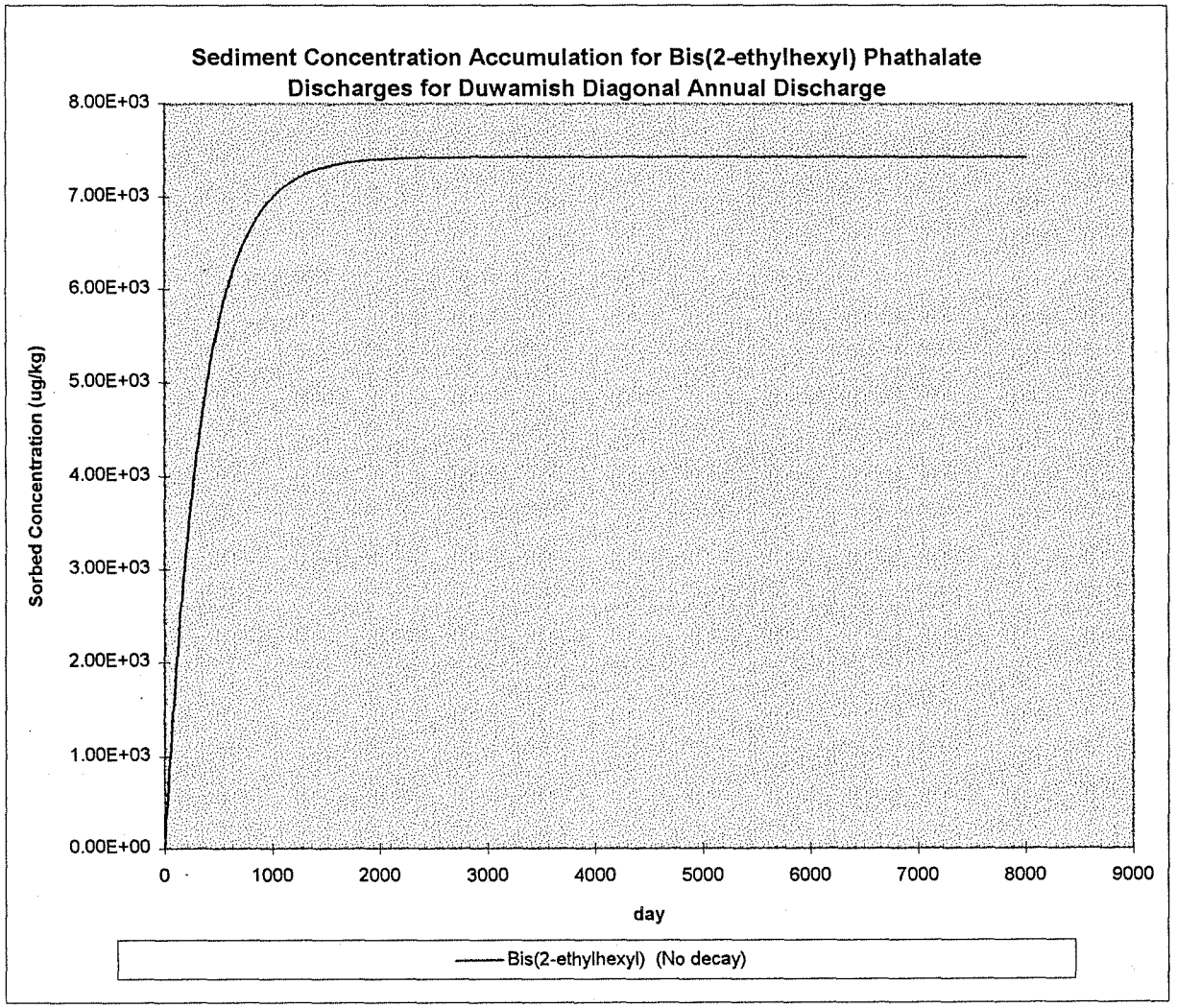
TSS = 3.72

Mixing Section

Width = 1000

TSS = 126

Chemical	Annual Conditions Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Organic Carbon Mixed (ug/kg)	SQS (ug/kg)	Cm/Csqs	Fitted widt where: $Cm = C_{sq}$ (ft)
Bis(2-ethyl	4,700	3.96	506.77	9.45	961	47,000	0.02	18



Steady input

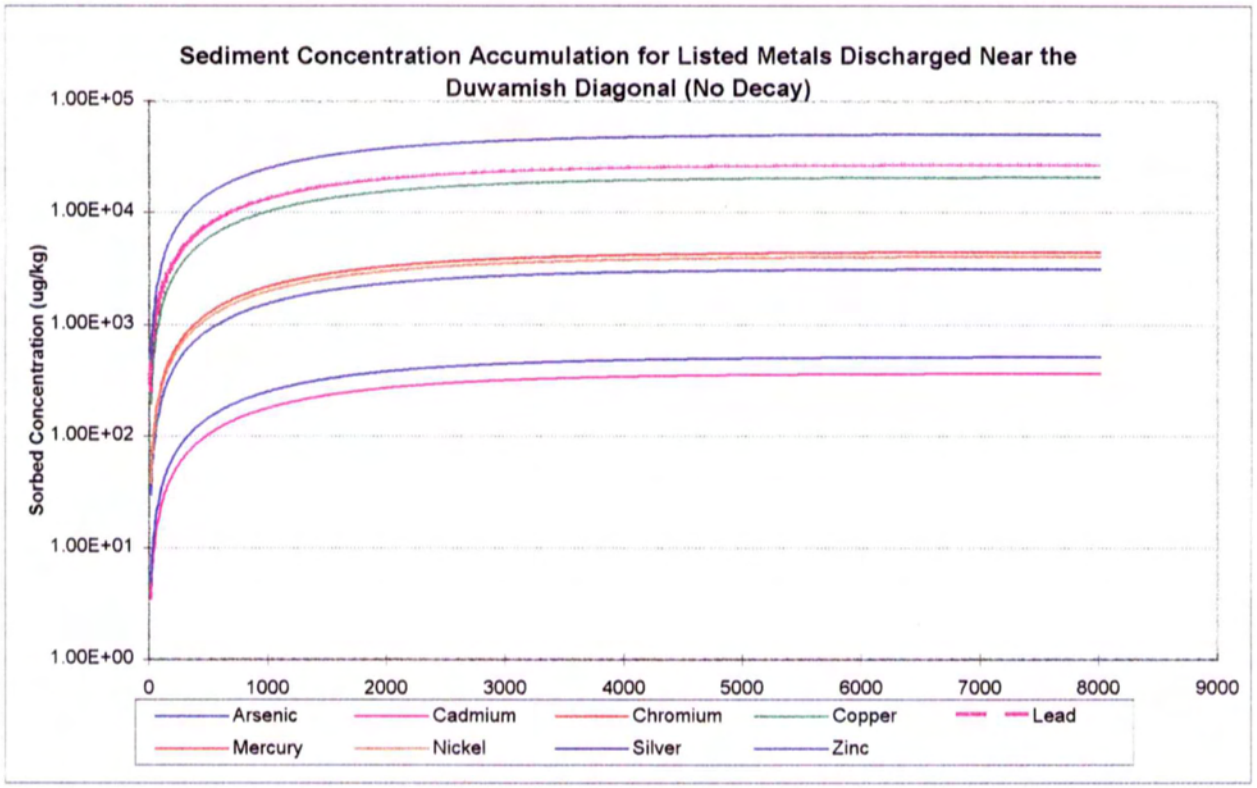
Duwamish Section
Width = 1000
TSS = 3.72

Mixing Section
Width = 1000
TSS = 126

g/sqcm/yr 0.98

Time to reach steady-state for a decay (1/yr)
k = 0 9.42 yrs
k = .0843 7.00 yrs

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	C_m Mixed (ug/kg)	C_{sqs} SQS (ug/kg)	Cm/Csqs	Fitted width where: $C_m = C_{sqs}$ (ft)
Arsenic	512,000	3.96	506.77	9.52	3,176	57,000	0.06	15
Cadmium	262,200	3.96	506.77	1.46	371	5,100	0.07	40
Chromium	512,000	3.96	506.77	13.47	4,494	260,000	0.02	1
Copper	7,337,000	3.96	506.77	43.6	20,997	390,000	0.05	1
Lead	988,200	3.96	506.77	65.87	26,136	450,000	0.06	10
Mercury	408	3.96	506.77	0.31	0	410	0.00	1
Nickel	500,000	3.96	506.77	12.34	4,085			
Silver	156,000	3.96	506.77	2.74	521	6,100	0.09	60
Zinc	344,650	3.96	506.77	178.8	51,411	410,000	0.13	90



Steady input

Duwamish Section

Width = 1000

TSS = 3.72

Mixing Section

Width = 175

TSS = 126

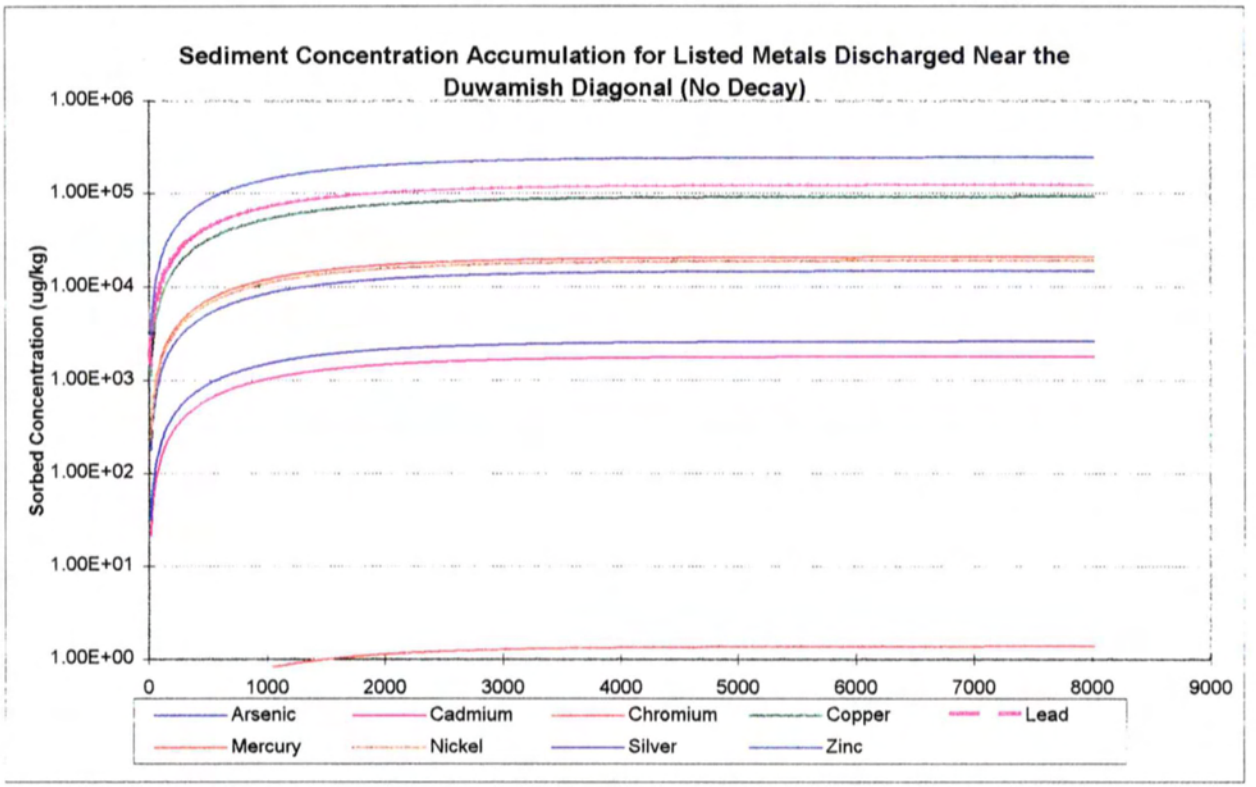
g/sqcm/yr 1.25

Time to reach steady-state for a decay (1/yr)

k = 0 7.33 yrs

k = .0843 5.78 yrs

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Csqs SQS (ug/kg)	Cm/Csqs	Fitted width where: Cm = Csqs (ft)
Arsenic	512,000	5.09	89.51	9.52	15,109	57,000	0.27	15
Cadmium	262,200	5.09	89.51	1.46	1,833	5,100	0.36	40
Chromium	512,000	5.09	89.51	13.47	21,378	260,000	0.08	1
Copper	7,337,000	5.09	89.51	43.6	93,271	390,000	0.24	1
Lead	988,200	5.09	89.51	65.87	120,678	450,000	0.27	10
Mercury	408	5.09	89.51	0.31	1	410	0.00	1
Nickel	500,000	5.09	89.51	12.34	19,455			
Silver	156,000	5.09	89.51	2.74	2,663	6,100	0.44	60
Zinc	344,650	5.09	89.51	178.8	250,083	410,000	0.61	90



Steady input

Duwamish Section

Width = 1000

TSS = 3.72

Mixing Section

Width = 16.6

TSS = 126

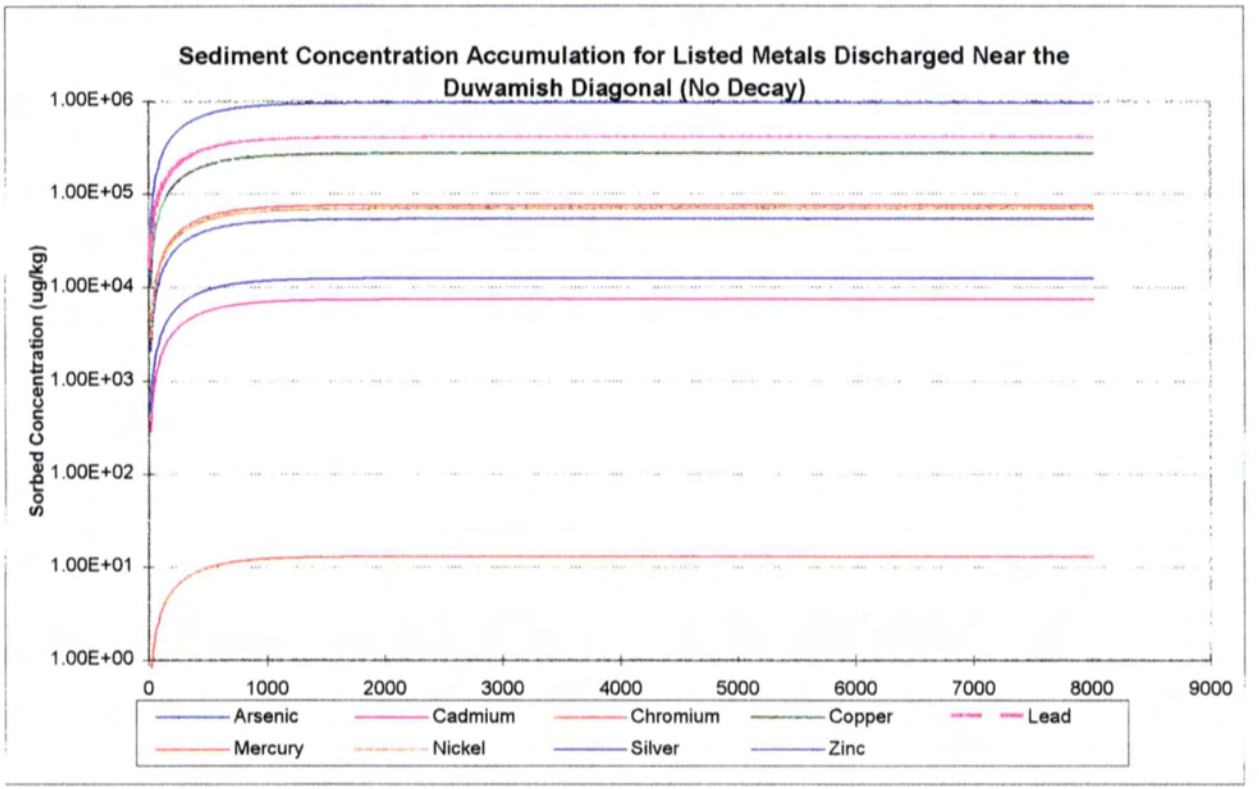
g/sqcm/yr 4.13

Time to reach steady-state for a decay (1/yr)

k = 0 2.23 yrs

k = .0843 2.06 yrs

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	C_m Mixed (ug/kg)	C_{sqs} SQS (ug/kg)	Cm/Csqs	Fitted width where: $C_m = C_{sqs}$ (ft)
Arsenic	512,000	16.73	9.40	9.52	54,219	57,000	0.95	15
Cadmium	262,200	16.73	9.40	1.46	7,562	5,100	1.48	40
Chromium	512,000	16.73	9.40	13.47	76,716	260,000	0.30	1
Copper	7,337,000	16.73	9.40	43.6	275,057	390,000	0.71	1
Lead	988,200	16.73	9.40	65.87	395,046	450,000	0.88	10
Mercury	408	16.73	9.40	0.31	13	410	0.03	1
Nickel	500,000	16.73	9.40	12.34	70,104			
Silver	156,000	16.73	9.40	2.74	12,600	6,100	2.07	60
Zinc	344,650	16.73	9.40	178.8	969,139	410,000	2.36	90



DIAG1'.XLS

Time to reach steady-state for a decay (1/yr)

k = 0 9.10 yrs

k = 1.0 1.84 yrs

Duwamish Section

Width = 1000

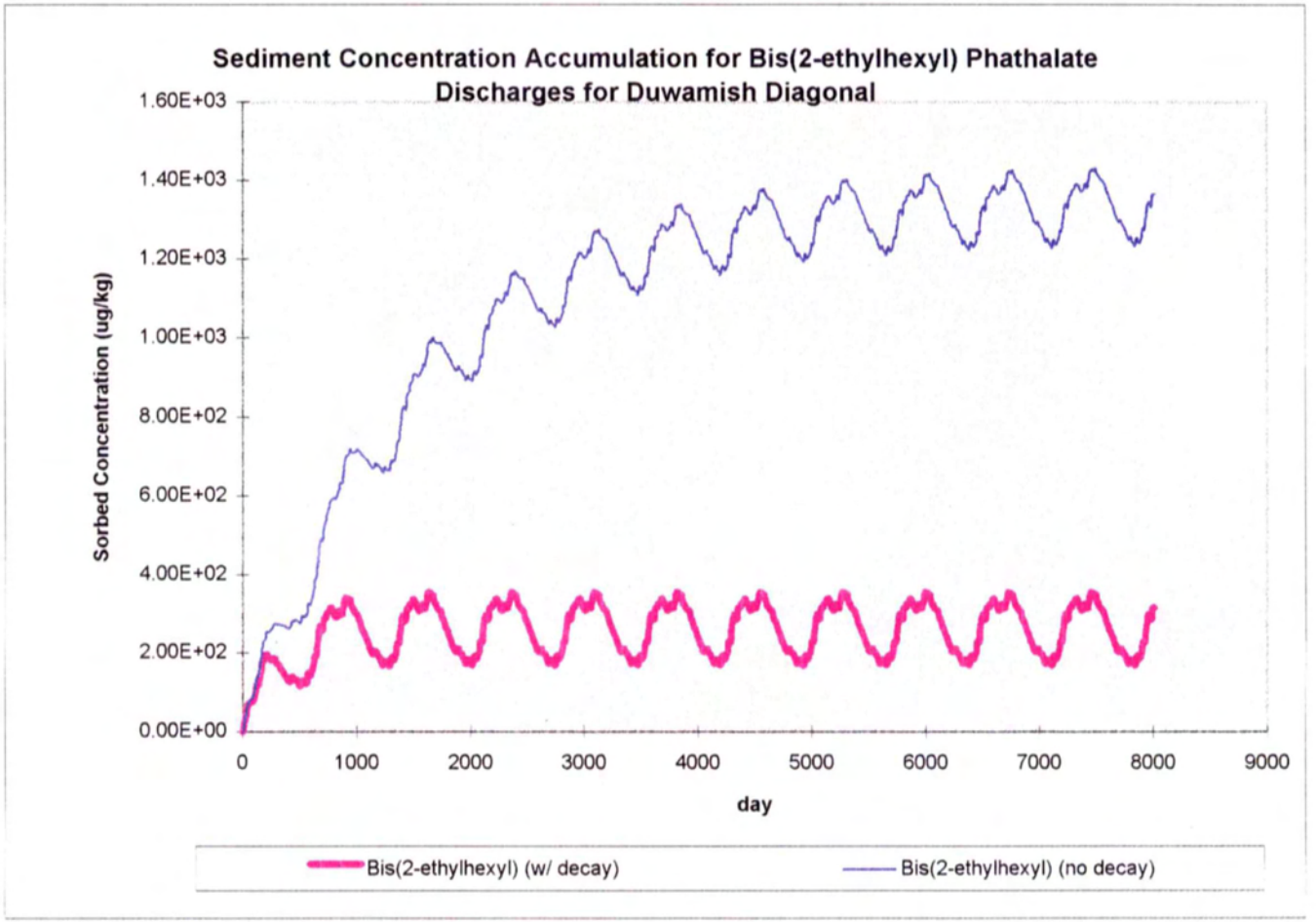
TSS = 3.72

Mixing Section

Width = 1000

TSS = 126

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Organic Carbon Csqs SQS (ug/kg)	Cm/Csqs	Fitted widt where: Cm = Csqs (ft)
Bis(2-ethyl	4,700	4.04	382.23	9.45	1,338	47,000	0.03	35



DIAG1'.XLS

Time to reach steady-state for a decay (1/yr)

k = 0	6.36 yrs
k = 1.0	1.69 yrs

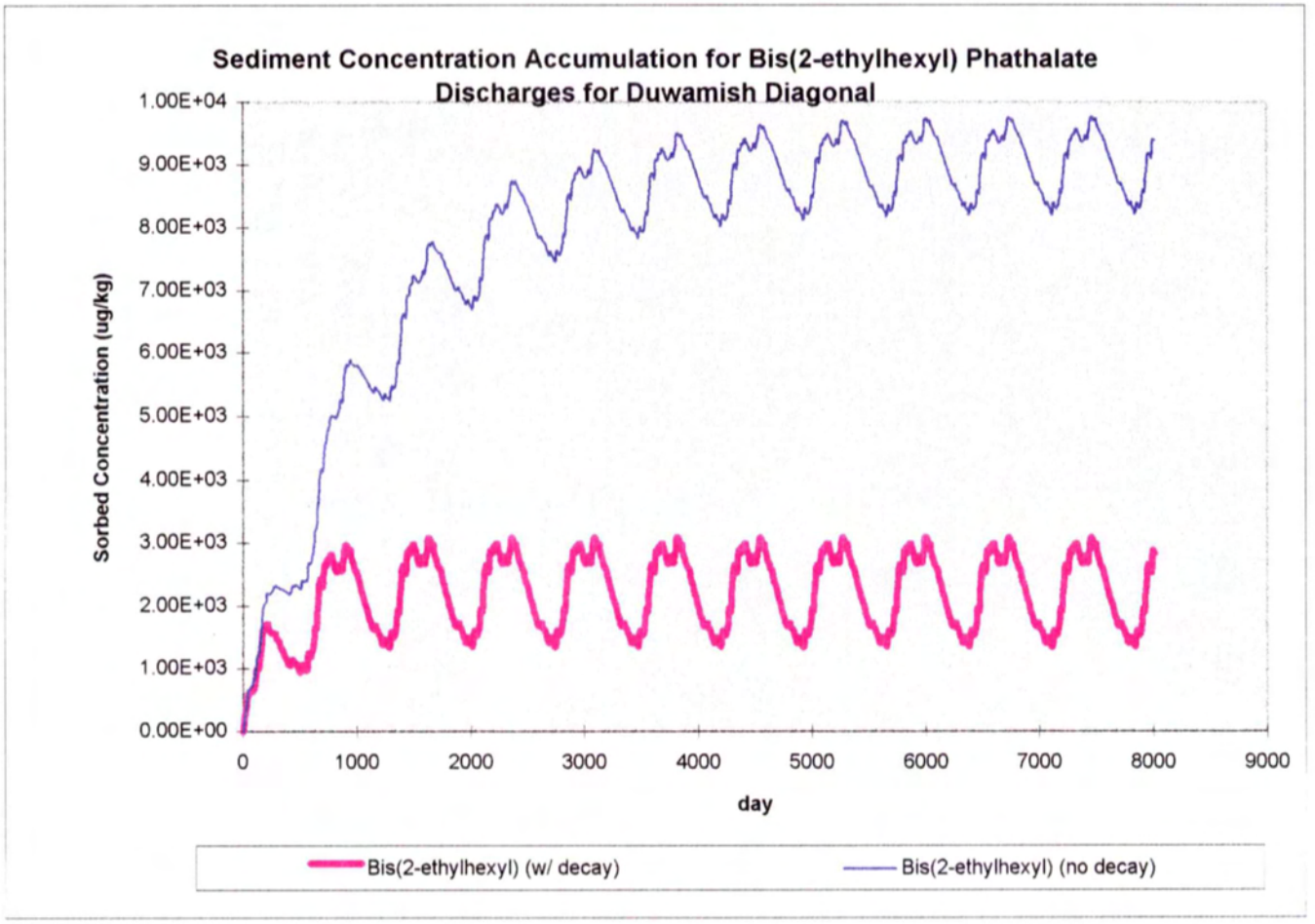
Duwamish Section

Width =	1000
TSS =	3.72

Mixing Section

Width =	175
TSS =	126

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Organic Carbon Csqs SQS (ug/kg)	Cm/Csqs	Fitted widt where: Cm = Csqs (ft)
Bis(2-ethyl	4,700	5.53	67.71	9.45	9,059	47,000	0.19	35



DIAG1'.XLS

Time to reach steady-state for a decay (1/yr)

k = 0 1.61 yrs

k = 1.0 0.95 yrs

Duwamish Section

Width = 1000

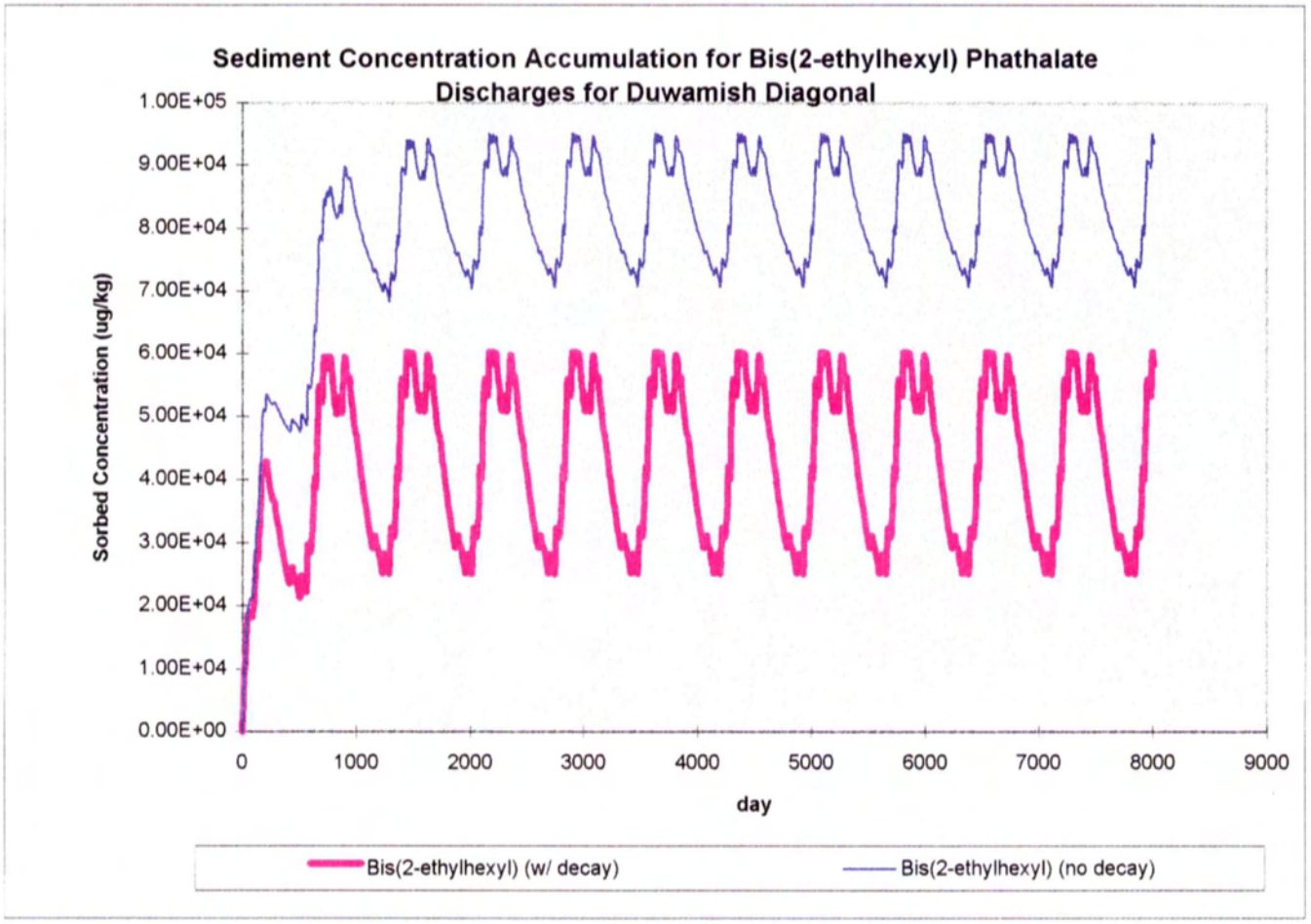
TSS = 3.72

Mixing Section

Width = 16.6

TSS = 126

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Organic Carbon Csqs SQS (ug/kg)	Cm/Csqs	Fitted widt where: Cm = Csqs (ft)
Bis(2-ethyl	4,700	20.41	7.33	9.45	83,670	47,000	1.78	35

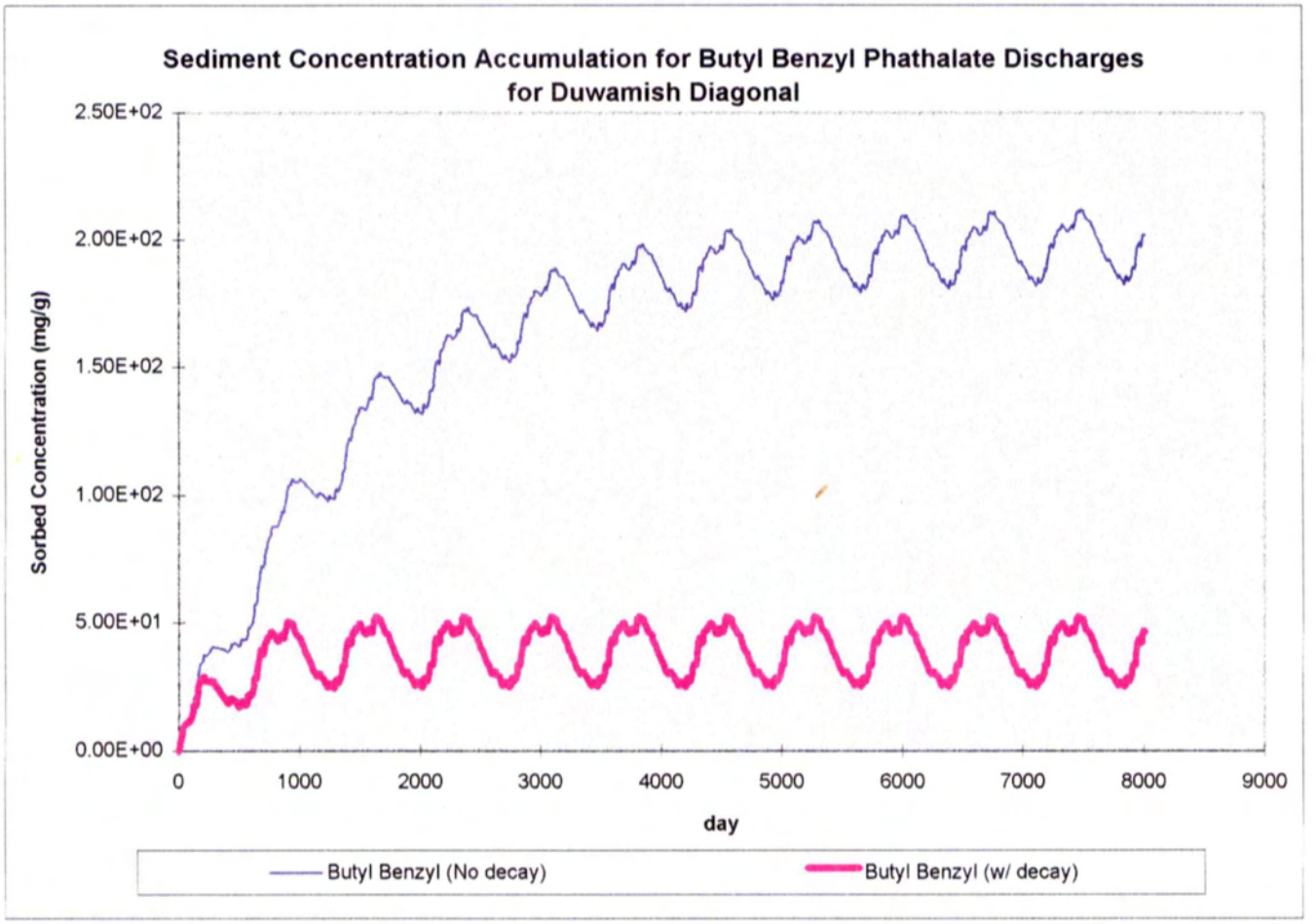


Time to reach steady-state for a decay (1/yr)

k = 0	9.10 yrs
k = 1.0	1.84 yrs

Duwamish Section
Width = 1000
TSS = 3.72
Mixing Section
Width = 1000
TSS = 126

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Organic Carbon Csqs SQS (ug/kg)	Cm/Csqs	Fitted width where: Cm = Csqs (ft)
Butyl	2,966	4.04	382.23	2.2	198	4,900	0.04	52



DIAG1'.XLS

Time to reach steady-state for a decay (1/yr)

k = 0 6.36 yrs

k = 1.0 1.69 yrs

Duwamish Section

Width = 1000

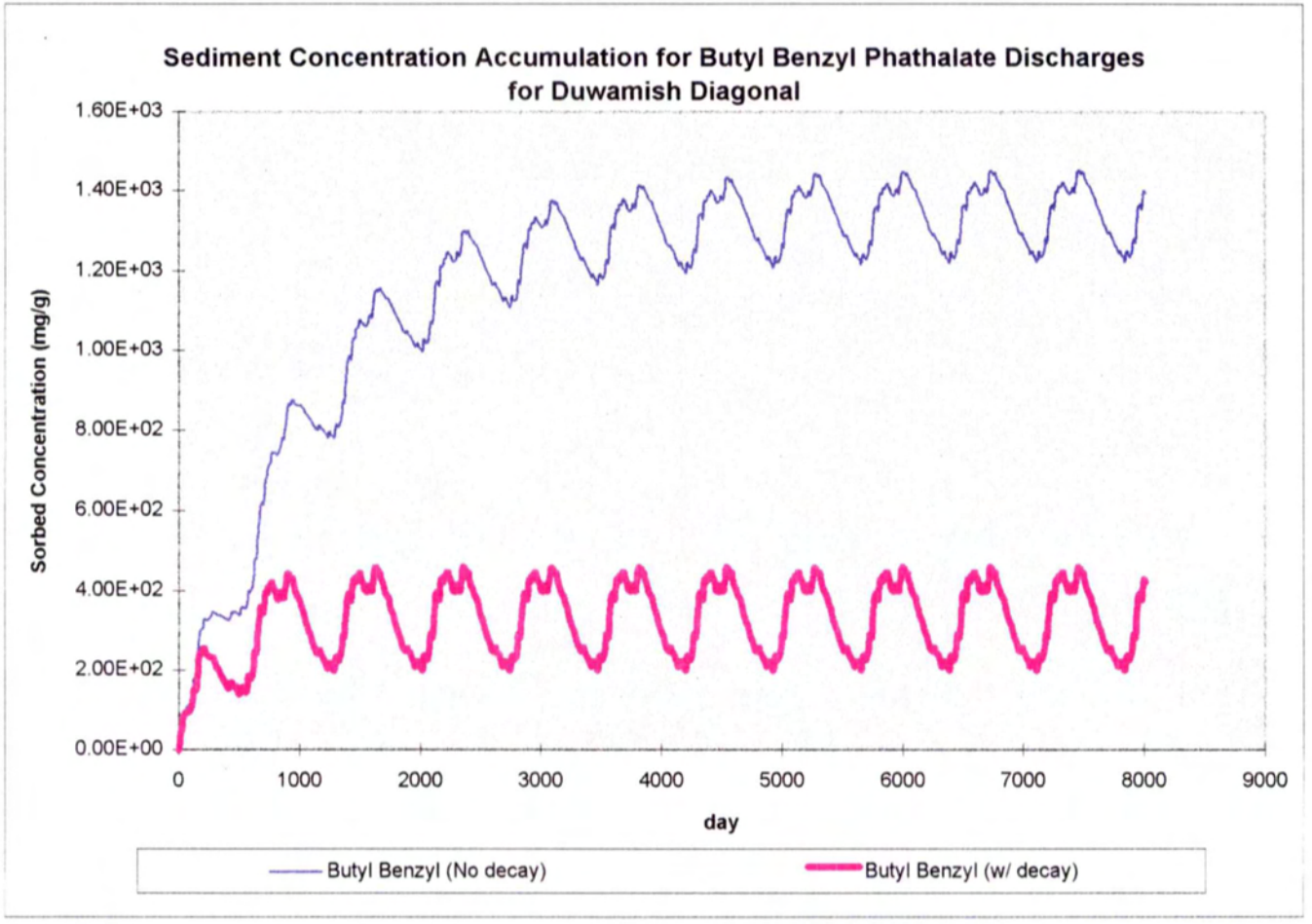
TSS = 3.72

Mixing Section

Width = 175

TSS = 126

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Organic Carbon Csqs SQS (ug/kg)	Cm/Csqs	Fitted width where: Cm = Csqs (ft)
Butyl	2,966	5.53	67.71	2.2	1,348	4,900	0.28	52



DIAG1'.XLS

Time to reach steady-state for a decay (1/yr)

k = 0 1.61 yrs

k = 1.0 0.95 yrs

Duwamish Section

Width = 1000

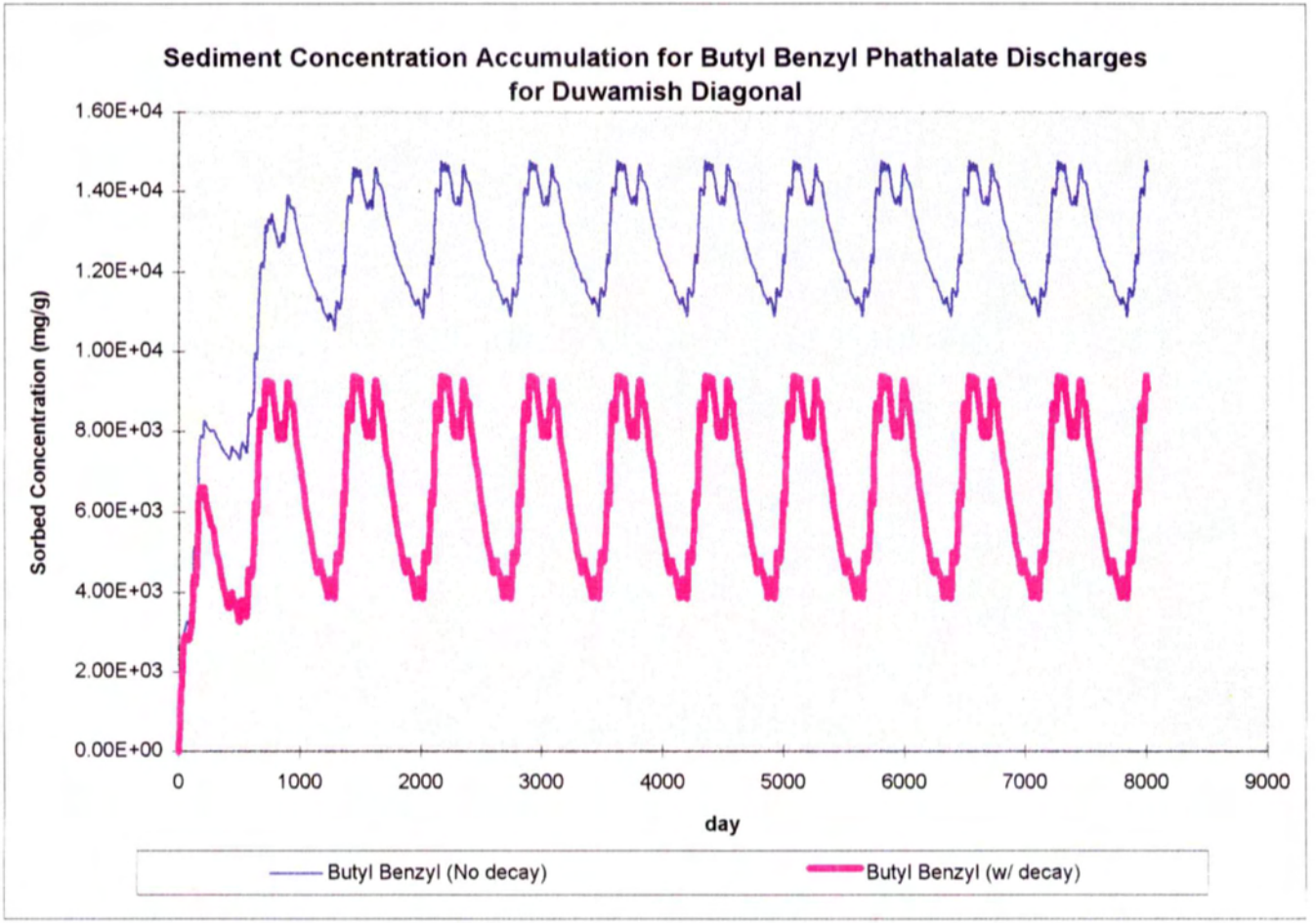
TSS = 3.72

Mixing Section

Width = 16.6

TSS = 126

Metal	Partition (l/kg)	TSS (mg/l)	Dilution	CSO Conc. (ug/l)	Cm Mixed (ug/kg)	Organic Carbon Csqs SQS (ug/kg)	Cm/Csqs	Fitted width where: Cm = Csqs (ft)
Butyl	2,966	20.41	7.33	2.2	12,940	4,900	2.64	52



11/17/97
P.R.

IMPLICATION OF FLOW VOLUME CHANGE AT DIAGONAL CS0/SD

It has been determined that the predicted annual volume of storm water discharged from the Diagonal storm drain should be 1230 MGY instead of the 685 to 713 MGY initially provided by the City of Seattle. This increase in stormwater combined with increased CSO volume estimates by KC produce significant changes in the results of the sediment recontamination modeling.

The increase in stormwater volume has resulted because the Hanford drainage basin was not factored into the original predictions of Diagonal stormwater flow made by the City. Based on the drainage basin map recently provided by the City (Oct1997), the estimated surface area for Hanford basin is about 1500 acres. Previously, when KC run the CSO model using a surface area of 1573 acres for the Hanford basin, the predicted total annual stormwater volume for Diagonal plus Hanford basin was 1230 MGY. Given the uncertainty in determining the true surface area, it is felt that 1573 acres is close enough to 1500 acres that it is not warranted to rerun the CSO model to obtain any different flow volume than the 1230 MGY value.

KC has also determined that annually there may be over 20 CSO events that could add to the volume discharged through the Diagonal outfall. The predicted volume of CSO is unclear because KC believes that some of the monitoring sites are backwatered thus resulting in excess water elevations and flow calculations. The maximum predicted annual CSO overflow volume is 290 MGY, but Bob Swarner believes that the actual annual volume is only 50 - 80 MGY. It is not possible to verify these numbers at this time without new accurate monitoring data.

The sediment recontamination model was rerun to calculate new projections for the mixing widths due to the increased volumes of stormwater and CSO at the Diagonal discharge. Due to the uncertainty of the true discharge volume, three flow volumes ~~of~~ were used to cover a range of possibilities. If only stormwater is considered, the new volume is 1230 MGY. But when CSO volumes of 90 MGY and 290 MGY are added, total flows increase to 1320 MGY and 1520 MGY respectively. These are the 3 flows that were modeled in July 1997.

The new mixing widths for the increased flow volumes are added to the attached Table 3-1 to allow comparison with previous results. These results show there is a linear increase in mixing width as flow volume increases. The three metals cadmium, silver, and zinc have the largest mixing width values ranging from 103.8 feet to 277.2 feet, but these are thought to be unrealistic because these metals did not exceed the SMS values at the site.

The two organic compounds that are of concern are the phthalates because they greatly exceeded the SMS at the site. The three new flow values represent increases of 72.5 %, 85.1%, and 113.2% greater then the value originally used. For bis(2-ethylhexyl) phthalate the mixing width increased from 35 feet to 60.6 , 64.8 , and 74.6 feet, respectively. For butyl benzyl phthalate the mixing width increased from 52 feet to 90.0 , 96.2, and 110.8 feet, respectively.

We are now back to the same place we were in July 1997 when we were unable to interpret whether these larger values mean there will be recontamination. To obtain additional input, a list of questions was prepared for Ray Walton, who is the modeling consultant on the project.

Ratio CSO/SD conc.

Table 3-1
RESULTS OF METSED RECONTAMINATION MODELING FOR VARIABLE LOAD

	Compound	Modeled CSO Concentrations (µg/L)	SQS (µg/kg)	Maximum Width (ft.) to Achieve Cmix=Csqs	REVISED DIAGONAL STORMWATER 1230 MGY. Σ = 72.5% > CSO = 0%	(+90 CSO) 1320 MGY Σ = 85.1% > CSO = 6.8%	(+290 CSO) 1520 MGY Σ = 113.2% > CSO = 19.1%
	DISCHARGE VOLUME			713 MGY			
3.4	Arsenic	9.52 (2.75)	57,000	17	29.4	31.5	36.2
2.6	Cadmium	1.16 (0.55)	5,100	60	103.8	192.3	127.9
1.8	Chromium	13.17 (7.3)	260,000	<1	< 2	< 2	< 2.2
.9	Copper	43.6 (47)	390,000	<1	< 2	< 2	< 2.2
1.6	Lead	67.87 (39)	450,000	8	13.8	14.8	17.1
2.5	Mercury	0.31 (0.12)	410	<1	< 2	< 2	< 2.2
1.1	Nickel	12.34 (11.18)	Not available	–	—	—	—
—	Silver	2.74 (0.0)	6,100	95	164.3	175.9	202.5
1.2	Zinc	178.8 (145)	410,000	130	224.9	240.6	277.2
1.3	Bis(2-ethylhexyl) phthalate	9.45 (7.15)	47,000	35	60.6	64.8	74.6
3.7	Butyl benzyl phthalate	2.2 (0.59)	4,900	52	90.0	96.2	110.8

( )=Actual Diagonal Stormdrain concentrations; refer to Appendix I.