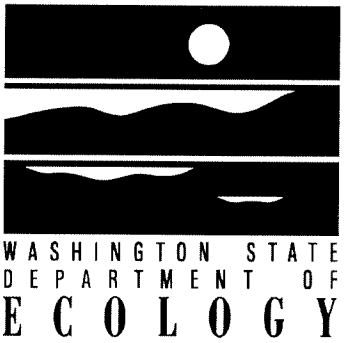

DRAINAGE BASIN TRACING STUDY: PHASE II CHEMICALS FOUND IN STORM DRAINS, WHATCOM CREEK AND SQUALICUM HARBOR IN BELLINGHAM, WASHINGTON

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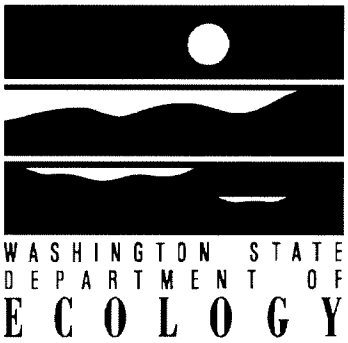

DRAINAGE BASIN TRACING STUDY: PHASE II CHEMICALS FOUND IN STORM DRAINS, WHATCOM CREEK AND SQUALICUM HARBOR IN BELLINGHAM, WASHINGTON

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by
James Cubbage

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TABLE OF CONTENTS

ABSTRACT

To follow-up an earlier study that investigated contaminants in storm drain sediments (PTI 1991: Phase 1). Drainage basin source tracing study), eight storm drains in three drainage basins (small watersheds) were examined for chemicals in retained sediments. Samples were collected from manholes above the outfalls where the drains empty into Puget Sound. In addition, sediments from a marina and sediments from an urban creek were analyzed to also assess potential impacts to Bellingham Bay. These sediments were analyzed for metals (arsenic, copper, cadmium, chromium, nickel, lead, mercury and zinc), volatile organic compounds, semivolatile compounds, PCBs and chlorinated hydrocarbon pesticides, total organic carbon, and grain size. *Hyalella* and Microtox® bioassays were conducted at the two creek sites.

Several different chemicals were found in the samples collected for this study. Most of the contaminants were phthalates, phenol, lead and zinc. Polycyclic aromatic hydrocarbons (PAH) were found in most samples but none were above marine sediment criteria or freshwater sediment guidelines. Some drains also had high concentrations of toluene and 4-methylphenol. One of the two Whatcom Creek samples showed significant effects on bioassay organisms and although no conclusive cause could be found for the effects, pentachlorophenol was highest at the site where the effects occurred.

Most of the chemicals found at high concentrations near the mouths of the drainage basins were not found higher up in stormwater systems in this study. Conversely, the chemicals found at high frequencies or at high concentrations in this study were not found in the Phase 1 study. Some of these differences may be due to seasonal variations.

SUMMARY AND CONCLUSIONS

1) Several different chemicals were found in the storm drain and creek samples collected for this study.

2) Most of the contaminants were phthalates, 4-methylphenols, phenol, lead and zinc. Copper was also anomolously high at one site. Volatile aromatic compounds were also high at one site. With the exception of zinc, these chemicals were not characterized in the initial Phase 1 study as problem chemicals based on the fact their concentrations did not exceed criteria. Conversely, the chemicals identified as problem chemicals in the Phase 1 project were not found in high concentrations in the portions of the basins examined in this phase.

3) Freshwater bioassays were affected in one site in Whatcom Creek. At both sites, 4-methylphenol was above criteria, but at the affected site pentachlorophenol was above criteria. The exact cause of the bioassay effects at this site is unknown.

4) Detected polycyclic aromatic hydrocarbons, were below criteria and guidelines at all sites.

5) Chlorinated phenols were found in high concentrations along Bennett Avenue at site BELL162. The potential source of this contamination is not apparent.

RECOMMENDATIONS

1) Search for sources of contamination to sample sites BELL092, BELL132, and BELL162.

2) Continue to examine the sources of pentachlorophenol in Whatcom Creek and search for the source of high concentrations of pentachlorophenol at BELL162 (Bennett Avenue). Determine sources of 4-methylphenol through literature search and examination of the drainage.

3) Consider developing a sediment trap suitable for storm drains so that sediments could be studied in drainages that do not ordinarily retain suitable sediments (see **Sampling strategy and sampling locations**).

ACKNOWLEDGEMENTS

Lucy Pebles of the Northwest Regional Office of the Washington State Department of Ecology assisted this study in the following areas: selection of sample locations, collection of samples, review of this report, and overall study design. The assistance of the City of Bellingham Engineering Department and Street Department in storm drain mapping, traffic control, and access hole identification is greatly appreciated. Dale Norton, Larry Goldstein, Bill Yake, and Lucy Pebles all reviewed this report. I thank all these people.

INTRODUCTION

An earlier study examined contaminants in sediments recovered from storm drains in Bellingham. The goal of that 1990 study (PTI 1991) was to trace potential sources of contamination to Bellingham Bay. It found several basins (small watershed of several drain lines that empty into one outfall) that had high concentrations of polycyclic aromatic hydrocarbons (PAH), metals and pentachlorophenol in storm drains that eventually discharge directly into Bellingham Bay or into Whatcom Creek.

To follow up this earlier research, Environmental Investigations of the Department of Ecology collected and examined sediments in drainages that had high contaminant levels in Phase 1. This report describes that work. In addition to further study outlined in the Phase 1 report, additional samples were taken in Squalicum Harbor to assess possible pollution in the harbor and samples were taken from Whatcom Creek to assess potential contamination in this urban creek.

METHODS

Sampling Strategy and Sample Locations

Figure 1 shows a typical storm drain system and terms used in this report. Figure 2 shows locations of samples taken in this study.

The Phase 1 study ranked four storm drain basins as high priority for continued study (BELL03, BELL08, BELL09, and BELL16). Basins BELL03 and BELL08 are small, have few drains and needed no additional storm drain tracing to locate possible sources. The possible sources of contamination are being investigated. BELL09 had high concentrations of metals and BELL16 high concentrations of PAH. These basins were selected for follow-up examination for all chemicals. One basin (BELL13) was ranked as medium priority and it was also examined in this study. Thus, three basins (BELL09, BELL13, BELL16) were examined within the storm drain system at a minimum of two locations. Sites within the basin were numbered in a series by basin. From Phase 1 results, BELL09 was selected for high concentrations of metals arsenic, cadmium, chromium, copper, and zinc. BELL13 was selected for 1,4-dichlorobenzene, copper, and zinc. BELL16 was selected for high molecular weight PAH and dibenzofuran. Concentrations of these chemicals exceeded Marine Sediment Standards (Washington State Department of Ecology 1991).

Additionally, in this study, two samples were collected in Whatcom Creek, two samples were collected in Squalicum Harbor to examine potential contamination of the harbor, and three samples were collected in the Maritime Contractors shipyard area. These last three samples are reviewed in a separate report (Cubbage 1993).

Locations for sample sites and sampling dates are listed in Table 1. Additional locale maps are shown in Appendix 1. Samples sites were selected within the drainage basins to provide some sense of the location of the contamination source. Candidate sample sites were

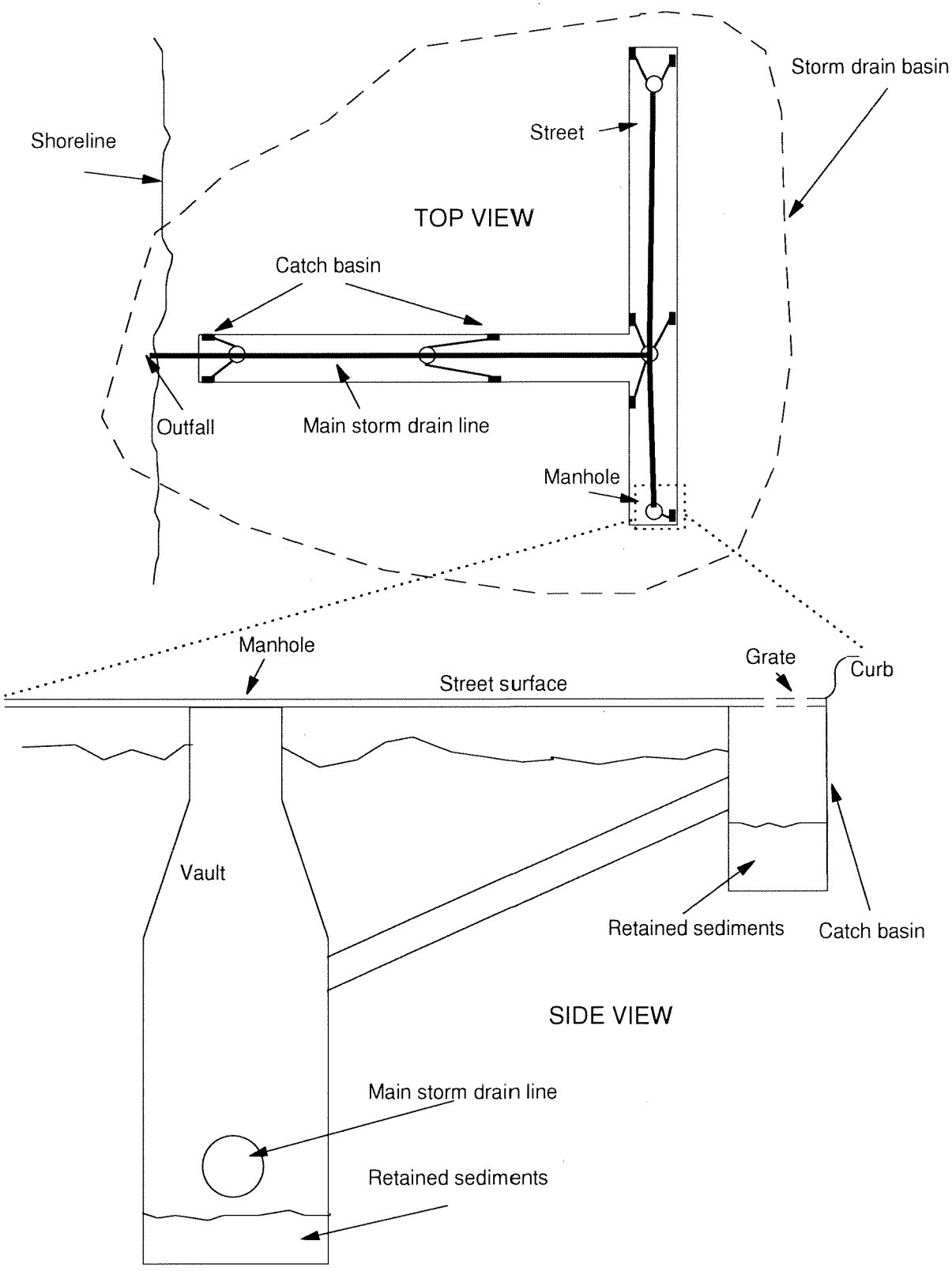

Figure 1. Typical storm drain system with terms used in report.

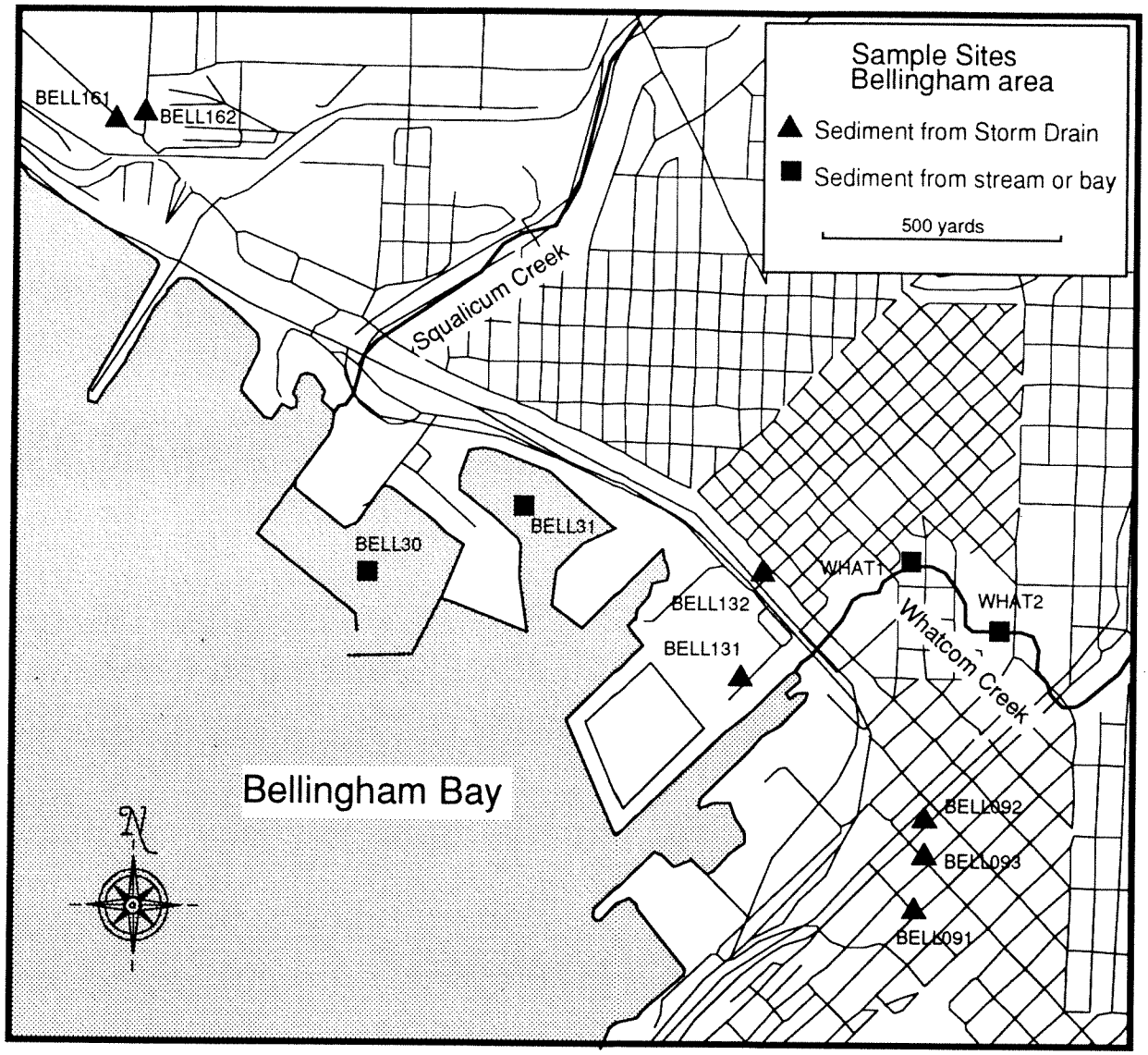

Figure 2. Location of study sites in Bellingham area.

examined on January 1993 prior to sampling to assure that the storm drain structure did retained suitable sediments. Many of these potential sample locations did not trap sediments and some of those that did trapped only gravel. Some overall areas of interest did not collect sediments in the storm drains. Thus, collection sites were not always the optimal locations with respect to storm drain tracing, but were a suitable compromise between location and structure that allowed sediment collection. A possible solution to this ongoing problem of compromise in sediment source tracing is the design and fabrication of sediment traps that are suitable for storm drains. These traps could be placed in optimal locations, allowed to collect sediment, and removed after the study was completed.

Table 1. Location description of all sample sites. Detailed maps are shown in Appendix 2.

Location	Date	Description
WHAT1	03/30/93	On left bank between Prospect and Grand 48 45.3', 122 28.7'
WHAT2	03/30/93	On left bank just west of Cornwal St bridge 48 45.25', 122 28.55'
BELL30	03/29/93	Squalicum Marina 48 45.34', 122 30.23' (see Appendix figure)
BELL31	03/29/93	Squalicum Marina 48 45.43', 122 29.91' (see Appendix figure)
BELL091	05/26/93	Garden at E. Laurel
BELL092	05/26/93	Parking lot on east side of Railroad north of Maple
BELL093	05/26/93	Maple between Chestnut and Railroad
BELL131	05/26/93	Bottom of "C" street near Bellingham Marine industries
BELL132	05/26/93	"F" street between Holly and Roeter along alley
BELL161	05/26/93	Marine Drive near Bennett
BELL162	05/26/93	Bennett near Marine Drive in front of fire station

Field Sampling

Samples from manholes were collected with a stainless steel pivoting scoop attached to an aluminum extension pole. Sampling personnel never entered manholes to collect samples. Sediments from Whatcom Creek were collected with an Emery pipe dredge from shore and with stainless steel scoops near shore. The two marine samples were collected with a modified 0.1m^2 Van Veen grab sampler from the a 21 foot Boston Whaler operated by the Department of Ecology. Only the top 2 cm of sediments collected with the grab were taken for analysis. Marine samples were collected following methods described in Puget Sound Estuary Protocols (EPA 1986a).

All samples were homogenized in stainless steel beakers or stainless steel buckets, and subsamples poured into priority pollutant clean jars. Volatile organic samples were taken into VOA bottles directly from the grab samples or from the beakers prior to homogenization. Sampling equipment was cleaned with detergent, 10% nitric acid, deionized water, and pesticide analysis grade acetone.

Laboratory Methods

All samples were analyzed for metals, volatile organic compounds, semivolatile organic compounds, chlorinated pesticides and PCBs, total organic carbon, and grain size and chlorinated phenols/phenoxy herbicides. In addition, samples from Whatcom Creek were tested with *Hyalella* and Microtox® bioassays. The *Hyalella* bioassay is a chronic test (10 day) that measures organism survival at the end of the test period. Microtox® is a luminescent bacteria and the test relies upon a reduction in light output as a function of toxicity. Table 2 reviews analyses done by site and the laboratories that conducted the work. All samples were analyzed under Puget Sound Estuary Program protocols (EPA 1986a) or

Table 2. Analytical Methods.

Analysis	Method	Reference	Laboratory	Analysis at site										
				WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Grain size	Seives and pipettes	EPA 1986a (PSEP)	Soil Technology, Seattle	X	X	X	X	X	X	X	X	X	X	X
% Moisture	Dry @ 105 degrees C	APHA 1985	Soil Technology, Seattle	X	X	X	X	X	X	X	X	X	X	X
Total organic carbon	CO2/Combustion	EPA 1986a	ARI Laboratories, Seattle	X	X	X	X	X	X	X	X	X	X	X
Arsenic	Atomic Absorption	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Cadmium	Inductively Coupled Argon Plasma	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Chromium	Inductively Coupled Argon Plasma	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Copper	Inductively Coupled Argon Plasma	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Mercury	Cold Vapor Atomic Absorption	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Lead	Inductively Coupled Argon Plasma	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Nickel	Inductively Coupled Argon Plasma	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Silver	Inductively Coupled Argon Plasma	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Zinc	Inductively Coupled Argon Plasma	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Semivolatiles (BNA)	GC/MS Method 8270	EPA 1986b	EPA/Ecology, Manchester	X	X	X	X	X	X	X	X	X	X	X
Pest/PCB	GC/EC Method 8080	EPA 1986b	EPA/Ecology, Manchester; ARI Laboratories	X	X	X	X	X	X	X	X	X	X	X
VOAs	GC/MS Method 8240	EPA 1986b	EPA/Ecology, Manchester; ARI Laboratories	X	X	X	X	X	X	X	X	X	X	X
Chlorinated Phenols	GC/EC Method 8250 (modified)	EPA 1986b	ARI Laboratories, Seattle	X	X	X	X	X	X	X	X	X	X	X
Microtox Bioassay	Percent light reduction	EPA 1986a (PSEP)	Parametrix, Seattle	X	X									
Hyalella bioassay	Survival	ASTM 1990	Parametrix, Seattle	X	X									

alternately following the EPA Contract Laboratory Program (CLP) laboratory protocols. Metals were analyzed with the strong acid (nitric and hydrochloric) digestion, not total digestion utilizing hydrofluoric acid.

Quality Assurance

Two matrix spike and two matrix spike duplicates were run to assess precision. PCB analysis was run with an acid clean-up to remove some interference. Sample analyses were reviewed for quality and the "case narratives" for overall quality appear in Appendix 2. The data were acceptable for use with the qualifications attached.

Data Analysis Methods

Concentrations of chemicals were compared with both marine sediment criteria and freshwater sediment guidelines. The marine criteria are derived from the lowest Apparent Effects Threshold (AET) among several bioassay organisms and change in benthic community structure. These lowest AETs are the criteria reflected in sediment management standards (Washington Dept. of Ecology 1991). The freshwater guidelines were derived for Ontario Province (Persaud *et al.* 1993) and are the concentrations above which severe effects can be expected on the benthic community. These severe effects levels are based on indigenous organisms, were derived with the screening level concentration approach and are not described as chronic or acute effects. Concentrations above these criteria and guidelines are considered by the issuing agencies to be harmful to organisms in the environment.

RESULTS AND DISCUSSION

Metals

Concentrations of metals at the different locations as well as criteria developed to determine toxic effects in marine and freshwater sediments are shown in Table 3. Few sites exceeded these criteria. Those exceeding criteria were Bell092, the catch basin in the parking lot and BELL132, another catch basin that had high concentrations of lead and zinc, and other contaminants associated with automobiles. BELL161, a storm drain that opens into a ditch, also exceeded criteria and had extremely high concentrations of copper.

All other sites were below criteria. The grain size data presented in Table 3 shows that the sediments were primarily sand with the exception of the two marine sites Bell30 and Bell31. The predominance of sand indicates higher flow speeds and less deposition. Metals tend to occur at higher concentrations in finer sediments because of the proportionally greater surface area on which to adsorb. Thus, if finer grained sediment could be collected and sampled, metals concentrations would probably be higher. No readily accepted method exists to normalize sediments for comparisons among different grain sizes.

Table 3. Metals concentrations found in Bellingham Bay sediments and from storm drains and creeks.

Site	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162	Marine	Freshwater
Lab No.	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197	Criteria*	Guidelines**
METALS mg/kg dry weight													
Arsenic	4.4	3.2	12	9.6	1.8 J	6.8 N	2.8 J	9.6 N	6.2 N	19 N	4.6	57	33
Cadmium	0.56 P	0.49 P	0.93 P	1.1 P	0.55 P	3.1 P	0.8 P	0.41 P	1.4 P	0.47 P	0.76 P	5.1	10
Chromium	34	28	97	86	18	56	19	29	41	33	25	260	110
Copper	24	21 B	67	200	25	86 N	28 N	64 N	79 N	1700 N	72 N	390	110
Lead	58	55	20	21	72	390	75	5.9 P	450	140	50	450	250
Mercury	0.15	0.051 P	0.20	0.29	0.040 P	0.25	0.10	0.050 P	0.16	0.027 P	0.030 P	0.41	2
Nickel	32	25	170	140	23	42	22	19	42	31	38		75
Silver	1.1 J	1.5 J	0.3 U	0.3 U	0.3 U	0.3 U	0.91	0.3 U	0.45 P	0.3 U	0.3 U	6.1	
Zinc	140 E	120 E	130 E	140 E	130 N	610 N	150 N	120 N	410 N	170 N	200 N	410	820
%Solids	63%	77%	42%	48%	58%	56%	80%	62%	46%	75%	73%		
%Sand***	81%	97%	3%	10%	93%	81%	96%	87%	85%	73%	93%		
%Silt***	15%	3%	50%	38%	5%	15%	2%	13%	14%	16%	6%		
%Clay***	4%	0%	47%	52%	2%	4%	2%	0%	1%	11%	1%		

*Marine Sediment Criteria from Dept of Ecology 1991 Chapter 173-204 WAC

**Freshwater sediment quality guidelines - severe effect level (Persaud et al. 1992)

P=Metal detected above detection limit but below quantification limit.

N=Estimate due to spike result below of control limits: values shown are minimum estimates.

B=Chemical found in method blank.

J=Result is an estimate.

U=Not found at quantification limit shown.

E=Concentration is estimate because of interference.

***Sand=(>62.5μm); Silt=(62μm-3.9μm); Clay=(<3.9μm)

Outline=Found at or above one criterion

Semivolatiles

Table 4 shows concentrations of semivolatiles found in this study above detection limits in at least one site. Shaded values indicate chemicals found above detection limits. Appendix Table 1 shows detection limits of chemicals not found in any sample. Table 5 compares semivolatile concentrations to marine criteria and freshwater guidelines. Phthalates exceed the marine criteria. Phthalates are associated with plastics and are ubiquitous in the environment. Two phenols exceeded criteria. The criteria for 4-methylphenol is 670 ppb dry weight, and this concentration was exceeded at six sites. Phenol, which has a marine criteria of 420 ppb dry weight, exceeded criteria at all sites it was detected (5). Phenol is often found in association with wood decay. All other compounds are well below the two comparison criteria.

Pentachlorophenol (PCP) was found in the two Whatcom Creek sites with the higher concentration in the farther downstream site. The marine criteria for PCP is 360 ppb dry weight. The farther downstream site on Whatcom Creek (WHAT1) had one measurement of 430 ppb dry weight. Whatcom Creek feeds the Maritime Heritage Fish Hatchery which has experienced periodic fish kills (Kendra and Willms, 1990). Farther up the creek is Brooks Lumber, which may be leaching this chemical. Whether the occurrence of pentachlorophenol is from past or current discharge is not clear. Pentachlorophenol is somewhat water soluble and photodegrades so that compounds found in surface sediments probably have been recently deposited. Pentachlorophenol was also found at low concentrations at BELL091, BELL092 and BELL132. Along with other chlorinated phenols, PCP was found at concentrations above marine criteria at BELL162 along Bennett Avenue.

BELL132, the catch basin between Holly and Roeder Avenue had the highest concentrations of polycyclic aromatic hydrocarbons (PAHs). PAHs are products of incomplete combustion of fossil fuels. They are usually associated with internal combustion exhaust as well as urban street dust. BELL131 had high detection limits and thus could have had equivalent concentrations to other sites but were masked by the high detection limits.

Volatiles

Table 6 shows concentrations of volatile organic hydrocarbons found in at least one sample. The BTEX compounds (benzene, toluene, ethylbenzene, and xylene) were found at most of the storm drain and creek sites. These compounds are associated with petroleum products and indicate some leakage from vehicles or petroleum storage tanks in the area. At BELL091, the storm drain at Garden and E. Laurel, we found high concentrations of toluene. High concentrations of toluene along with comparably high concentrations of other BTEX compounds were found at BELL092 from a parking lot catch basin near Maple and Railroad. Also found at this location was 2-butanone, a component of plastic pipe. It is a common solvent (methylethylketone). A few other compounds were found at low concentrations in a few sites (p-isopropyltoluene, naphthalene and styrene). Volatile organic compounds looked for but not found above detection limits appear in Appendix Table 2.

Table 4. Semivolatiles found in Bellingham storm drains and creeks. (µg/kg dry weight)

Site =	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Lab Num =	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197
SEMIVOLATILES											
diethylphthalate	590 U	520 U	800 U	700 U	30 J	450 U	360 U	2300 U	610 U	410 U	390 U
butylbenzylphthalate	590 U	520 U	800 U	700 U	530 U	5800	170 J	2300 U	920	410 U	3300
carbazole	220 J	200 J	800 U	700 U	97 J	270 J	100 J	2300 U	340 J	410 U	130 J
pentachlorophenol	430 J	2600 U	4000 U	3500 U	5300 U	4500 U	3600 U	11000 U	6100 U	4100 U	2000 J
pentachlorophenol*	49 J	19 J	9.2 U	8.3 U	4 J	9 J	12 U	12 U	20 J	REJ	790
2,3,4,5-tetrachlorophenol*	N/A	N/A	N/A	N/A	25 U	25 U	25 U	25 U	25 U	REJ	100 J
2,4,5-trichlorophenol*	N/A	N/A	N/A	N/A	60 U	60 U	60 U	60 U	60 U	REJ	145 J
4-nitrophenol	1500 U	1300 U	2000 U	1800 U	14000	450 U	360 U	2300 U	610 U	410 U	390 U
benzyl alcohol	590 U	170 J	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
4-methyphenol	3800	1700	800 U	700 U	7000	6100	560	2300 U	4700	67 J	3900
phenol	590 U	520 U	1100	940	510 J	450 U	360 U	2300 U	510 J	410 U	2100
dimethylphthalate	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	6000
dibenzofuran	180 J	210 J	97 J	700 U	530 U	260 J	42 J	2300 U	440 J	410 U	100 J
retene	140 J	150 J	800 U	260 J	530 U	450 U	360 U	2300 U	610 U	71 J	180 J
PAH											
naphthalene	180 J	230 J	100 J	130 J	530 U	1300	360 U	2300 U	610 U	410 U	580
1-methylnaphthalene	84 J	78 J	800 U	700 U	140 J	450	130 J	2300 U	290 J	410 U	480
2-methylnaphthalene	66 J	82 J	61 J	62 J	160 J	500	140 J	2300 U	330 J	410 U	600
acenaphthylene	41 J	58 J	800 U	43 J	33 J	330 J	360 U	2300 U	130 J	410 U	390 U
acenaphthene	170 J	220 J	800 U	700 U	100 J	120 J	52 J	2300 U	350 J	410 U	82 J
fluorene	230 J	320 J	82 J	700 U	140 J	370 J	92 J	2300 U	990	410 U	150 J
phenanthrene	1900	2000	800 U	700 U	1100	2100	690	2300 U	3900	410 U	1200
anthracene	410 J	350 J	800 U	700 U	180 J	330 J	110 J	690 J	980	410 U	150 J
Sum LPAH w/o m-napthalenes	2900 J	3200 J	180 J	170 J	1600 J	4600 J	940 J	690 J	6400 J		2200
fluoranthene	2600	2900	800 U	790	1900	2300	980	2300 U	6600	410 U	1200
pyrene	1900	2300	800 U	700 U	510 J	1600	590 J	2300 U	610 U	410 U	860
benzo(a)anthracene	840	890	800 U	700 U	530	450 U	340	2300 U	3300	410 U	370
chrysene	1100	1100	800 U	700 U	780	1100	450	420 J	2700	410 U	600
benzo(b)fluoranthene	1100	1200	800 U	700 U	890	450 U	430	2300 U	3000	410 U	580
benzo(k)fluoranthene	590 U	520 U	800 U	700 U	430 J	450 U	240 J	2300 U	1800	410 U	230 J
benzo(a)pyrene	660 U	720 U	800 U	700 U	530 U	450 U	170 J	2300 U	610 U	410 U	250 J
ideno(1,2,3-cd)pyrene	490 J	510 J	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	240 J
dibenzo(a,h)anthracene	140 J	130 J	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
Sum HPAH	8200 J	9000 J	800	790	5000 J	5000	3200 J	420 J	17400		4300 J

U=No chemical present at detection limit shown
J=Quantity is an estimate
*=Results from analysis of more sensitive electron capture method
N/A=Not analyzed
=Found above detection limits

Table 5. Semivolatiles found at study sites compared to criteria and guidelines.

Site =	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162	Marine	Freshwater
Lab Num =	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197	Criteria**	Values***
SEMIVOLATILES													
(μg/kg dry weight)													
benzyl alcohol		170 J										57	
4-methylphenol	3800	1700			7000	6100	560		4700	67 J	3900	670	
phenol			1100	940	510 J				510 J		2100	63	
pentachlorophenol	430 J	19 J			4 J	9 J			20 J		2000	360	
(mg/kg organic carbon)													
diethylphthalate					0.7 J							61	
butylbenzylphthalate						85	7.7 J		14		110	4.9	
carbazole	6.2 J	4.4 J			2.2 J	4 J	4.5 J		5.1 J		4.3 J		
dimethylphthalate											200	61	
dibenzofuran	5.1 J	4.6 J	6.8 J			3.8 J	1.9 J		6.6 J		3.3 J	15	
retene	4 J	3.3 J		19 J						6.5 J	6 J		
PAH (mg/kg organic carbon)													
naphthalene	5.1 J	5 J	7 J	9.4 J		19					19	99	
1-methylnaphthalene	2.4 J	1.7 J			3.2 J	6.6	5.9 J		4.3 J		16		
2-methylnaphthalene	1.9 J	1.8 J	4.3 J	4.5 J	3.6 J	7.4	6.4 J		4.9 J		20	38	
acenaphthylene	1.2 J	1.3 J		3.1 J	0.8 J	4.9 J			1.9 J			66	
acenaphthene	4.8 J	4.8 J			2.3 J	1.8 J	2.4 J		5.2 J		2.7 J	16	
fluorene	6.5 J	7 J	5.7 J		3.2 J	5.4 J	4.2 J		15		5 J	23	160
phenanthrene	54	44			25	31	31		58		40	100	950
anthracene	12 J	7.7 J			4.1 J	4.9 J	5 J	31 J	15		5 J	220	370
Sum LPAH w/o m-napthalenes	82 J	70 J	13 J	12 J	36 J	68 J	43 J	31 J	96 J			370	
fluoranthene	73	63		57	43	34	45		99		40	160	1020
pyrene	54	50			12 J	24	27 J				29	1000	850
benzo(a)anthracene	24	19	56		12		15		49		12	110	1480
chrysene	31	24			18	16	20	19 J	40		20	110	460
total benzofluoranthenes	31	26			30 J		31 J		72		27 J	230	1340
benzo(a)pyrene							7.7 J				8.3 J	99	1440
ideno(1,2,3-cd)pyrene	14 J	11 J									8 J	34	320
dibenzo(a,h)anthracene	4 J	2.8 J										12	130
Sum HPAH	230 J	200 J			110 J		150 J	19 J			140 J	960	
Total organic carbon	3.5%	4.6%	1.4%	1.4%	4.4%	6.8%	2.2%	2.2%	6.7%	1.1%	3.0%		

Blank=No chemical present at detection limit
J=Quantity is an estimate
[ ]=found above Marine Criteria
*=Department of Ecology Sedimment Management Standards. Chapter 173-204 WAC. 1991.
**=Freshwater Sediment Guidelines: Severe Effects Level (Persaud et al. 1992)

Table 6. Volatile organic hydrocarbons found in at least one sample (μg/kg dry wt).

Site	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Lab Number	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197
methylene chloride	3 J	3 U	2 U	3 U	340 U	16 U	2.4 U	3.4 U	7.7 U	2.4 U	2.7 U
acetone	48 U	4 U	33 U	3 U	860 U	190	11 U	47 U	62 U	6.1 U	17
2-butanone	26 U	31 U	14 U	12 U	170 U	73	5.9 U	8.4 U	23 U	6.1 U	6.9 U
benzene	4 U	4 U	2 U	3 U	170 U	11	1.2 U	1.7 U	3.6 J	1.2 U	1.5
toluene	4 J	2 J	2 U	3 U	6700	10000	150	1.9	340	1.2 U	REJ U
ethylbenzene	4 U	4 U	2 U	3 U	170 U	14	2.2	3.9	11	1.2 U	11
styrene	1 J	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 J	3.9 U	1.2 U	1.4 U
total xylenes	4 U	4 U	2 U	3 U	170 U	43	24	7.4	12	2.4 U	85
p-isopropyltoluene	4	4	2 U	3 U	--	--	--	--	--	--	--
napthalene	4 U	1 J	2 U	3 U	--	--	--	--	--	--	--

U=No chemical present at detection limit shown.
J=Quantity is an estimate.
=Chemical found above quantification limit.
REJ=Analysis rejected.
--=Not analyzed.

Methylene chloride was found in one of the Whatcom Creek samples (WHAT1). This solvent is often used in laboratories for cleaning equipment but was not used to clean the field sampling equipment. Acetone was used to clean sampling equipment. Methylene chloride did not occur in the lab method blank wherein a "dummy" sample is analyzed with the other samples, and any contamination in laboratory equipment and glassware will appear in the blank. The acetone detections could be artifacts of the solvents used to prepare field equipment. However, based on the finding of methylene chloride in only one sample, methylene chloride likely was present in Whatcom Creek sediments though at a low concentration.

Chlorinated Pesticides and PCBs

Table 7a shows concentrations of pesticides and PCBs found in at least one sample. These compounds were found only in the storm drain samples. To compare with criteria, these compounds are converted to a total organic carbon-normalized basis in Table 7b. No compounds exceeded criteria for marine or freshwater sediments. PCBs were found in BELL091 and BELL092 (Garden and E. Laurel; Maple and Railroad parking lot catch basin). DDT was found in BELL092 and BELL132 ("F" street between Holly and Roeder). Other pesticides were found at BELL091, BELL132 and BELL162 (Bennett near fire station). Again, all these compounds were at least an order of magnitude below concentrations that would trigger other investigations in the marine environment and are below concentrations thought to have a significant effect on freshwater organisms. Appendix Table 3 shows detection limits of all chlorinated pesticides and PCBs looked for but not found in this study.

Bioassays

The two bioassay results for *Hyalella* and Microtox® are shown in Table 8.

The site near the mouth of Whatcom Creek (WHAT1) showed significant mortality compared to the control. Microtox® showed some effects, however, because no control or reference site was analyzed, the result could not be tested for significance. The source of this toxicity is not apparent although pentachlorophenol and 4-methylphenol were the only two chemicals from WHAT1 that were substantially above levels from WHAT2. Of those chemicals with criteria, PCP and 4-methylphenol were above marine criteria. PCP has been used in the watershed (see Semivolatile discussion above) and it is toxic to arthropods. The grain size structure is slightly different between the two sites, with WHAT1 having more fines, but both sites were predominantly sand. Of course, some other unmeasured toxicant might be affecting the bioassays.

Table 7a. Chlorinated pesticides and PCBs found in Bellingham storm drains and creeks. (μg/kg dry weight)

Site =	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Lab Num =	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197
4,4' -DDT	11 U	11 U	12 U	11 U	8.9 U	9.7	7.1 U	8.9 U	7.5 J	7.7 U	9.1 U
endrin ketone	11 U	11 U	12 U	11 U	8.9 U	15 U	12 U	15 U	17 U	7.7 U	13.0 J
gamma-Chlordane	10 U	5 U	6.1 U	5.5 U	5.7 J	4.5 U	3.7 U	4.6 U	7.1 J	4.0 U	4.1 U
alpha-Chlordane	5.5 U	5.5 U	6.1 U	5.5 U	2.6 J	4.5 U	3.7 U	4.6 U	5.0 J	4.0 U	4.1 U
PCB-1254	110 U	110 U	130 U	110 U	69 J	72	71 U	89 U	97 U	77 U	80 U

U=No chemical present at quantification limit shown
J=Quantity is an estimate
=chemical found above quantification limit
NR=Not reported as analyzed

Table 7b. Chlorinated pesticides and PCBs found in Bellingham storm drains and creeks. (mg/kg total organic carbon)

Site =	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162	Marine	Freshwater
Lab Num =	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197	Criteria*	Values**
4,4' -DDT						0.14			0.11 J				71
endrin ketone											0.43 J		130
gamma-Chlordane					0.13 J				0.11 J				6
alpha-Chlordane					0.059 J				0.075 J				6
PCB-1254					1.6 J	1.1						12	

J=Quantity is an estimate
No value=not found above detection limit
*=Department of Ecology Sedimment Management Standards. Chapter 173-204 WAC. 1991.
**=Freshwater Sediment Guidelines: Severe Effects Level (Persaud et al. 1992)

Table 8. Summary of bioassay results.

Sample Number	*Hyalella* avg % survival (n=5 reps of 10 organisms)	Microtox® light reduction (highest concen. blank corrected)
WHAT1 (14-8165)	*56	24
WHAT2 (14-8166)	86	7
West Beach Control	94	NA

*=Significant mortality compared with Control site (Dunnett's test at $p<0.05$)
NA=Not analyzed.

Summary of Analysis Results

Table 9 presents a summary of chemicals found in this study as well as bioassay results. One site, BELL131, had no chemicals above criteria or guidelines. Several other sites had only one chemical above criteria (WHAT2, BELL30, BELL31, BELL091, BELL093, BELL161). The lower Whatcom Creek sample (WHAT1) had two chemicals above criteria, pentachlorophenol and 4-methylphenol, as well as a significant bioassay response. Three sites exceeded criteria and/or guidelines for four or more chemicals: BELL092, BELL132 and BELL162. The first two had high concentrations of lead, zinc and butylbenzylphthalate. The last site had high concentrations of two kinds of phthalates, phenol and chlorinated phenols. These three sites all had high concentrations of 4-methylphenol. The high concentrations of copper at BELL161 are without clear explanation.

Comparisons to Phase 1

Generally, the chemicals that caused drainage basins to be priorities in Phase 1 (PTI, 1991) were not found at high concentrations in this follow-up work. The only exception to this tendency is zinc, which was found at high concentrations in Phase 1 at BELL09 and BELL13 and was found in high concentrations at BELL092 and BELL132. Lead also exceeded criteria at these two sites in this study. The portion of the basin BELL13 not checked in this study could still have high concentrations of chemicals noted in the Phase 1 study.

A partial explanation for the different results between the study phases could be seasonality. That is, different amounts of precipitation could vary the rate at which contaminants are flushed from the storm drain system. Overall though, the discharges to these storm drains may change over time and the chemicals retained may change as well.

Table 9. Review of chemicals found in sediments in this study.

Site	Description	Chemicals above Marine Criteria (Ecology 1991), Freshwater guidelines (Persaud et al. 1993), and/or significant bioassay results.	Other chemicals excluding metals found at over 2X quantification limit
WHAT1	Whatcom creek near Prospect	*Hyalella* bioassay mortality; some Microtox® response, pentachlorophenol, 4-methylphenol	PAH
WHAT2	Whatcom creek near Cornwall	4-methylphenol	pentachlorophenol, PAH
BELL30	Squalicum marina	phenol	--
BELL31	Squalicum marina	phenol	methylphenol
BELL091	Garden at E. Laurel	4-methylphenol	nitrophenol, toluene, PAH
BELL092	Parking lot near Railroad and Maple	lead, zinc, butylbenzylphthalate	toluene, acetone, xylenes, 2-butanone, 4-methylphenol, PAH
BELL093	Maple between Chestnut and Railroad	butylbenzylphthalate	toluene, xylenes, PAH
BELL131	Bottom of "C" Street	--	--
BELL132	"F" street between Holly and Roeder along alley	lead, zinc, butylbenzylphthalate, 4-methylphenol	toluene, PAH
BELL161	Marine Drive near Bennett	copper	--
BELL162	Bennett near Marine Drive	phenol, chlorinated phenols, butylbenzylphthalate, 4-methylphenol, dimethylphthalate	xylenes, acetone, PAH

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Appendix Table 1. Semivolatile quantification limits looked for but not found in Bellingham storm drains and creeks (μg/kg dry weight).

Site =	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Lab Num =	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197
2,4-dinitrophenol	12000 U	10000 U	16000 U	14000 U	11000 U	9000 U	7100 U	46000 U	12000 U	8200 U	7900 U
4-chloro-3-methylphenol	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
aniline	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
dimethyl nitrosamine	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
benzoic acid	590 U	640 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	2600 U
hexachloroethane	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
hexachlorocyclopentadiene	5900 U	5200 U	8000 U	7000 U	5300 U	4500 U	REJ	5700 U	6100 U	4100 U	980 U
isophorone	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
di-n-butylphthalate	590 U	570 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
n-nitrosodiphenylamine	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
hexachlorobutadiene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2,4,6-trichlorophenol	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2-nitroaniline	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2-nitrophenol	1500 U	1300 U	2000 U	1800 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2-chloronapthalene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
3,3'-dichlorobenzidine	1200 U	1000 U	1600 U	1400 U	1100 U	900 U	710 U	4500 U	1200 U	820 U	790 U
benzidine	1200 U	1000 U	1600 U	1400 U	1100 U	900 U	710 U	4500 U	1200 U	820 U	790 U
2-methylphenol	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
1,2-dichlorobenzene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
chlorophenol	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2,4,5 trichlorophenol	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
nitrobenzene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
3-nitroaniline	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
4-nitroaniline	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
4-bromophenyl-phenylethe	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2,4-dimethylphenol	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
1,4-dichlorobenzene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
4-chloroaniline	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
pyridine	1200 U	1000 U	800 U	760 U	1100 U	900 U	710 U	4600 U	1200 U	820 U	790 U
bis(2-chloroethyl)ether	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
bis(2-chloroethoxy)methane	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
bis(2-ethylhexyl)phthalate	2200 U	3000 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	930 U	390 U

U=No chemical present at detection limit shown

Appendix Table 1. Semivolatile quantification limits looked for but not found in Bellingham storm drains and creeks (μg/kg dry weight).

Site =	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Lab Num =	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197
di-n-octyl phthalate	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
hexachlorobenzene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
1,2,4-trichlorobenzene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2,4-dichlorophenol	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2,4-dinitrotoluene	1500 U	1300 U	2000 U	1800 U	1300 U	1100 U	890 U	5700 U	1500 U	1000 U	980 U
benzo(ghi)perylene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
4,6-dinitro-2-methylphenol	5900 U	5200 U	8000 U	7000 U	5300 U	4500 U	1800 U	23000 U	3100 U	2100 U	3900 U
1,3-dichlorobenzene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
2,6-dinitrotoluene	1500 U	1300 U	2000 U	1800 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
n-nitroso-di-n-propylamin	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
4-chlorophenyl-phenylene	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U
1,2 diphenylhydrazine	1200 U	1000 U	1600 U	1400 U	1100 U	900 U	710 U	4500 U	1200 U	820 U	790 U
bis(2,chloroisopropyl)ether	590 U	520 U	800 U	700 U	530 U	450 U	360 U	2300 U	610 U	410 U	390 U

U=No chemical present at detection limit shown

Appendix Table 2. Volatile organic hydrocarbons looked for but not found in any sample (μg/kg dry wt).

Site	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Lab Number	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197
carbon tetrachloride	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
chloroform	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,1,1-trichloroethane	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
bromomethane	4 U	4 U	2 U	3 U	340 U	16 U	2.4 U	3.4 U	7.7 U	2.4 U	2.7 U
chloromethane	4 U	4 U	2 U	3 U	340 U	16 U	2.4 U	3.4 U	7.7 U	2.4 U	2.7 U
dibromomethane	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
chlorethane	4 U	4 U	2 U	3 U	340 U	16 U	2.4 U	3.4 U	7.7 U	2.4 U	2.7 U
vinyl chloride	4 U	4 U	2 U	3 U	340 U	16 U	2.4 U	3.4 U	7.7 U	2.4 U	2.7 U
bromochloromethane	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
carbon disulfide	4 U	2 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
bromoform	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
bromodichloromethane	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,1-dichloroethane	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,1-dichloroethene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
trichlorofluoromethane	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
dichlorodifluoro methane	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
1,2-dichloropropane	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,1,2-trichloroethane	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
trichloroethene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,1,2,2-tetrachloroethane	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,2,3-trichlorobenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
hexachlorobutadiene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
2-chlorotoluene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
1,2-dichlorobenzene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,2,4-trimethylbenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
1,2-dibromo-3-chloropropa	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
1,2,3-trichloropropane	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
tert-butylbenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
isopropylbenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
butylbenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
4-chlorotoluene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
1,4-dichlorobenzene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,2-dibromomethane	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
1,2-dichloroethane	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
4-methyl-2-pentanone	4 U	4 U	2 U	3 U	170 U	40 U	5.9 U	8.4 U	19 U	6.1 U	6.9 U
1,3,5-trimethylbenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
bromobenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--

U=No chemical present at detection limit shown.
--=Not analyzed.

Appendix Table 2. Volatile organic hydrocarbons looked for but not found in any sample (μg/kg dry wt).

Site	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Lab Number	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197
chlorobenzene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,2,4-trichlorobenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
dibromochloromethane	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
tetrachloroethene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
sec-buthylbenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
1-3-dichloropropene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
cis - 1,2-dichloroethene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
trans-1,2-dichloroethene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,3-dichlorobenzene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
1,1-dichloropropene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
2-hexanone	4 U	4 U	2 U	3 U	170 U	40 U	5.9 U	8.4 U	19 U	6.1 U	6.9 U
1,1,1,2-tetrachloroethane	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
cis-1,3-dichloropropene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
trans-1,3-dichloropropene	4 U	4 U	2 U	3 U	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
propylbenzene	4 U	4 U	2 U	3 U	--	--	--	--	--	--	--
vinyl acetate	--	--	--	--	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
2-chloroethylvinylether	--	--	--	--	170 U	8.0 U	1.2 U	1.7 U	3.9 U	1.2 U	1.4 U
trichlorofluoromethane	--	--	--	--	340 U	16 U	2.4 U	3.4 U	7.7 U	2.4 U	2.7 U
1,1,2-trichlorotrifluoroethan	--	--	--	--	340 U	16 U	2.4 U	3.4 U	7.7 U	2.4 U	2.7 U

U=No chemical present at detection limit shown.
--=Not analyzed.

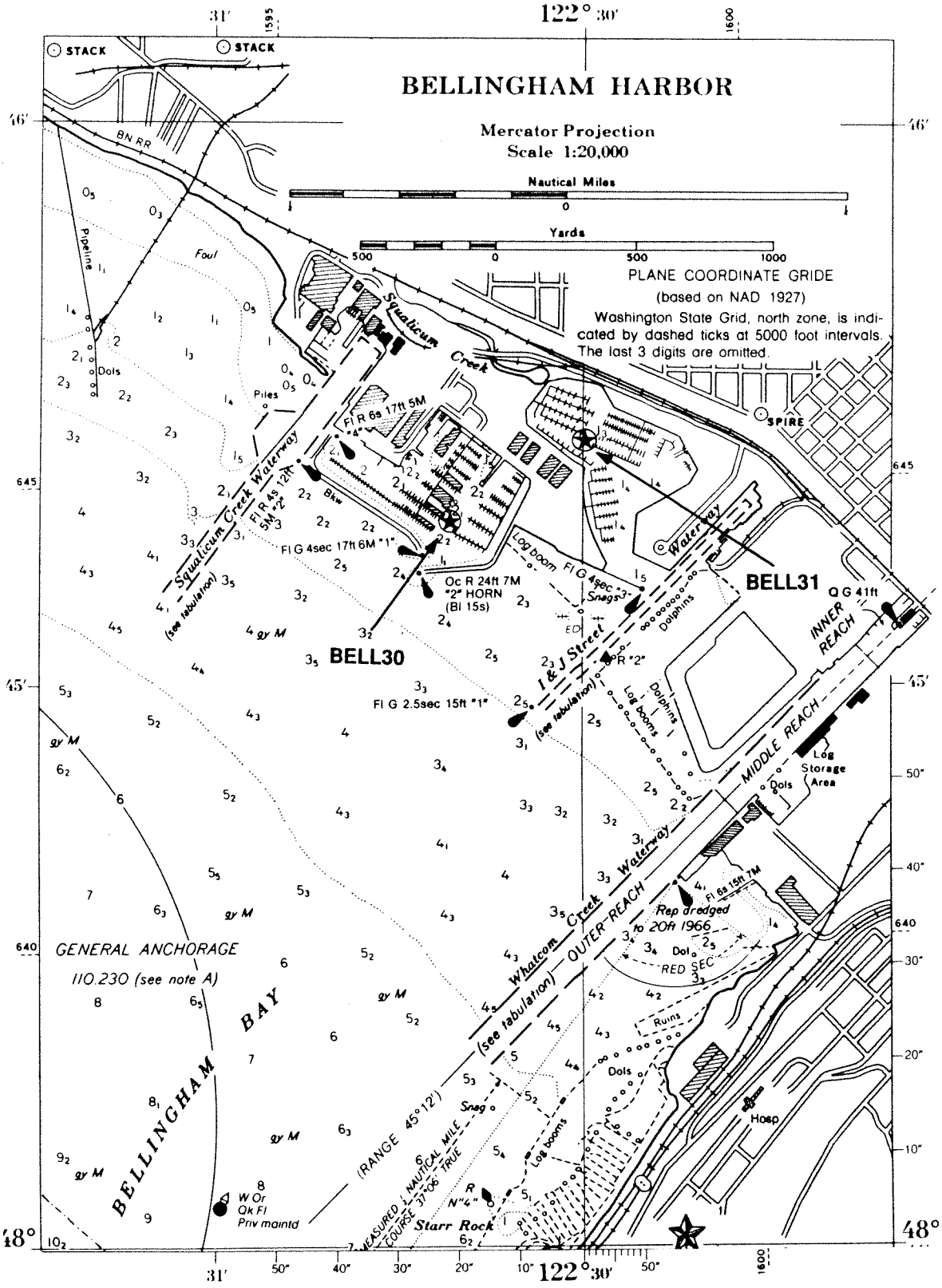
Appendix Table 3. Quantification limits of chlorinated pesticides and PCBs looked for but not found in Bellingham storm drains and creeks. (μg/kg dry weight)

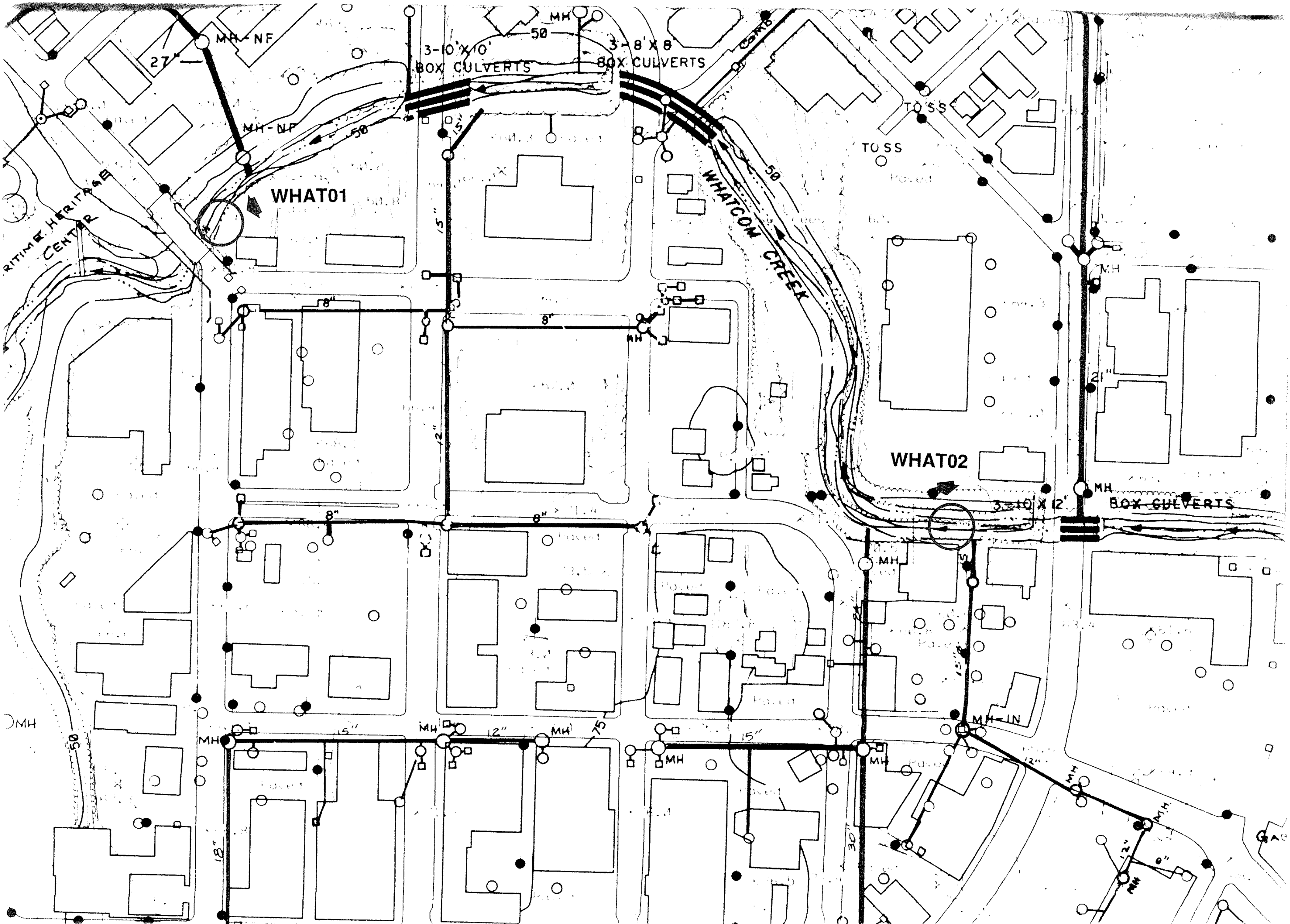
Site =	WHAT1	WHAT2	BELL30	BELL31	BELL091	BELL092	BELL093	BELL131	BELL132	BELL161	BELL162
Lab Num =	148165	148166	148169	148170	228190	228191	228192	228193	228194	228196	228197
alpha-BHC	5.5 U	5.5 U	6.1 U	5.5 U	4.6 U	4.5 U	3.7 U	4.6 U	5.0 U	4.0 U	4.1 U
beta-BHC	5.5 U	5.5 U	6.1 U	5.5 U	4.6 U	4.5 U	3.7 U	4.6 U	5.0 U	4.0 U	4.1 U
delta-BHC	10 U	12 U	6.1 U	5.5 U	4.6 U	4.5 U	3.7 U	4.6 U	5.0 U	4.0 U	4.1 U
gamma-BHC	5.5 U	5.5 U	6.1 U	5.5 U	4.6 U	4.5 U	3.7 U	4.6 U	5.0 U	4.0 U	4.1 U
heptachlor	5.5 U	5.5 U	6.1 U	5.5 U	4.6 U	4.5 U	3.7 U	4.6 U	5.0 U	4.0 U	4.1 U
aldrin	5.5 U	5.5 U	6.1 U	5.5 U	4.6 U	4.5 U	3.7 U	4.6 U	5.0 U	4.0 U	4.1 U
Heptachlor epoxide	5.5 U	5.5 U	6.1 U	5.5 U	4.6 U	4.5 U	3.7 U	4.6 U	5.0 U	4.0 U	4.1 U
endosulfan I	5.5 U	5.5 U	6.1 U	5.5 U	4.6 U	4.5 U	3.7 U	4.6 U	5.0 U	4.0 U	4.1 U
dieldrin	11 U	11 U	12 U	11 U	8.9 U	8.6 U	7.1 U	8.9 U	47 J	7.7 U	8.0 U
4,4'-DDE	11 U	11 U	12 U	11 U	8.9 U	8.6 U	7.1 U	8.9 U	9.7 U	7.7 U	8.0 U
endrin	11 U	11 U	12 U	11 U	8.9 U	8.6 U	7.1 U	8.9 U	9.7 U	7.7 U	8.1 U
endosulfan II	11 U	11 U	12 U	11 U	8.9 U	8.6 U	7.1 U	8.9 U	9.7 U	7.7 U	8.0 U
4,4'-DDD	11 U	11 U	12 U	11 U	8.9 U	8.6 U	7.1 U	8.9 U	9.7 U	7.7 U	8.0 U
endosulfan sulfate	11 U	11 U	12 U	11 U	8.9 U	8.6 U	7.1 U	8.9 U	9.7 U	7.7 U	8.0 U
methoxychlor	55 U	55 U	61 U	55 U	46 U	45 U	37 U	46 U	50 U	40 U	41 U
endrin aldehyde	11 U	11 U	12 U	11 U	8.9 U	8.6 U	7.1 U	8.9 U	9.7 U	7.7 U	8.0 U
toxaphene	550 U	550 U	610 U	550 U	460 U	450 U	370 U	460 U	500 U	400 U	410 U
PCB-1242/1016	110 U	110 U	130 U	110 U	89 U	86 U	71 U	89 U	97 U	77 U	80 U
PCB-1248	110 U	110 U	130 U	110 U	89 U	86 U	71 U	89 U	97 U	77 U	80 U
PCB-1260	110 U	110 U	130 U	110 U	89 U	86 U	71 U	89 U	97 U	77 U	80 U
PCB-1221	220 U	220 U	250 U	220 U	180 U	180 U	140 U	180 U	200 U	160 U	160 U
PCB-1232	110 U	130 U	130 U	110 U	89 U	86 U	71 U	89 U	97 U	77 U	80 U
PCB-1262	110 U	110 U	130 U	110 U	89 U	86 U	71 U	89 U	97 U	77 U	80 U
PCB-1268	110 U	110 U	130 U	110 U							

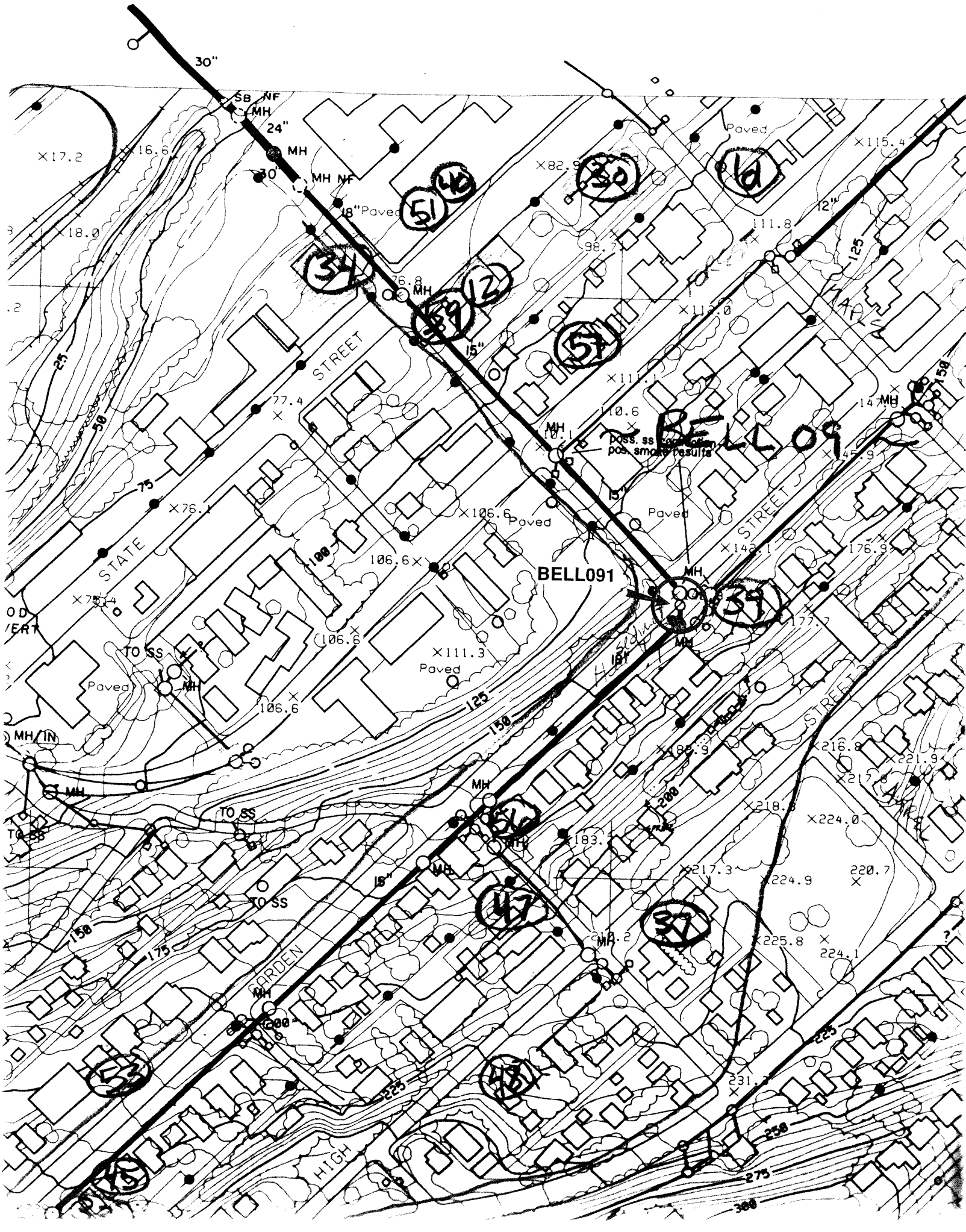
U = detection limit

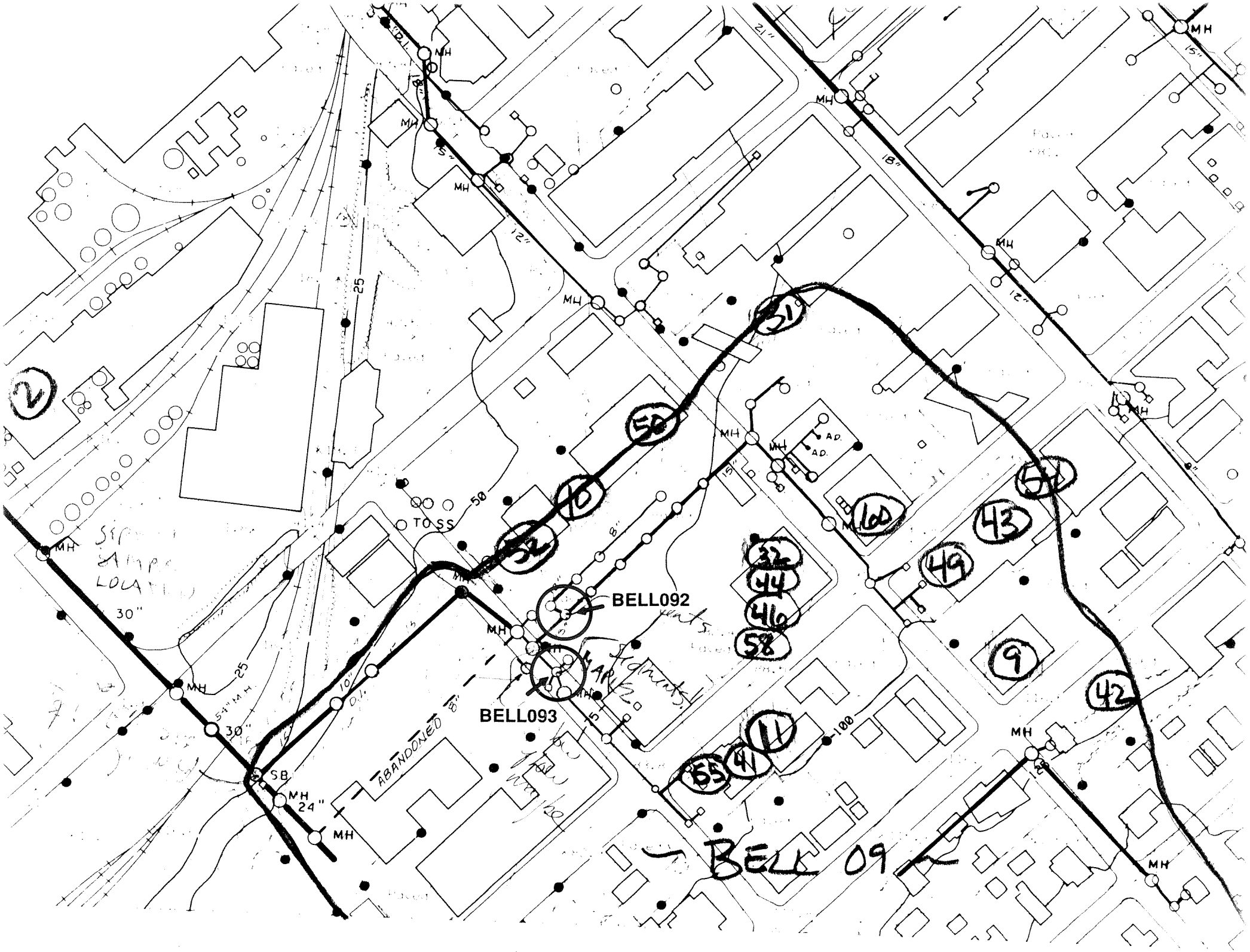
APPENDIX 1

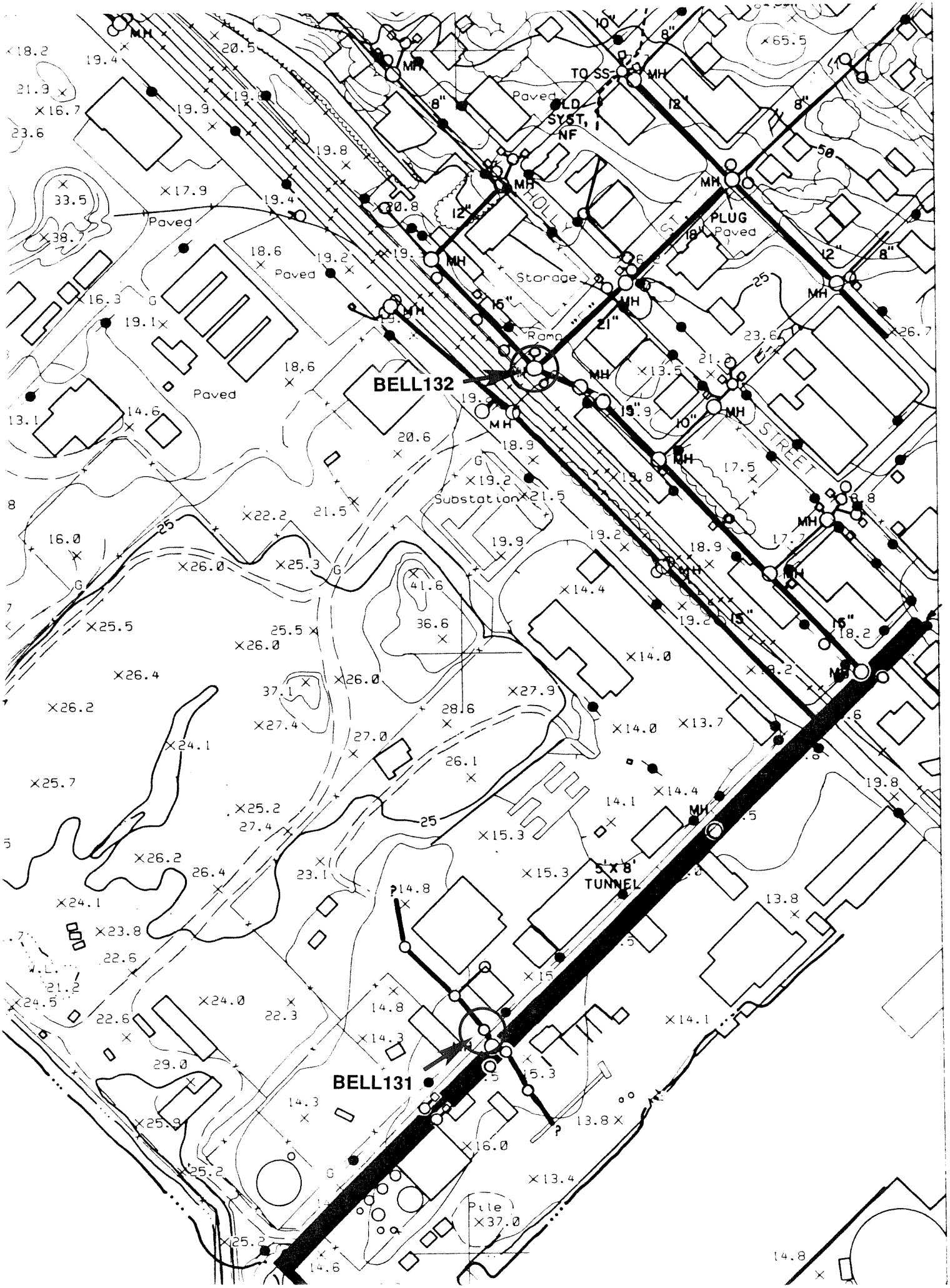
LOCALE MAPS OF SAMPLE LOCATIONS

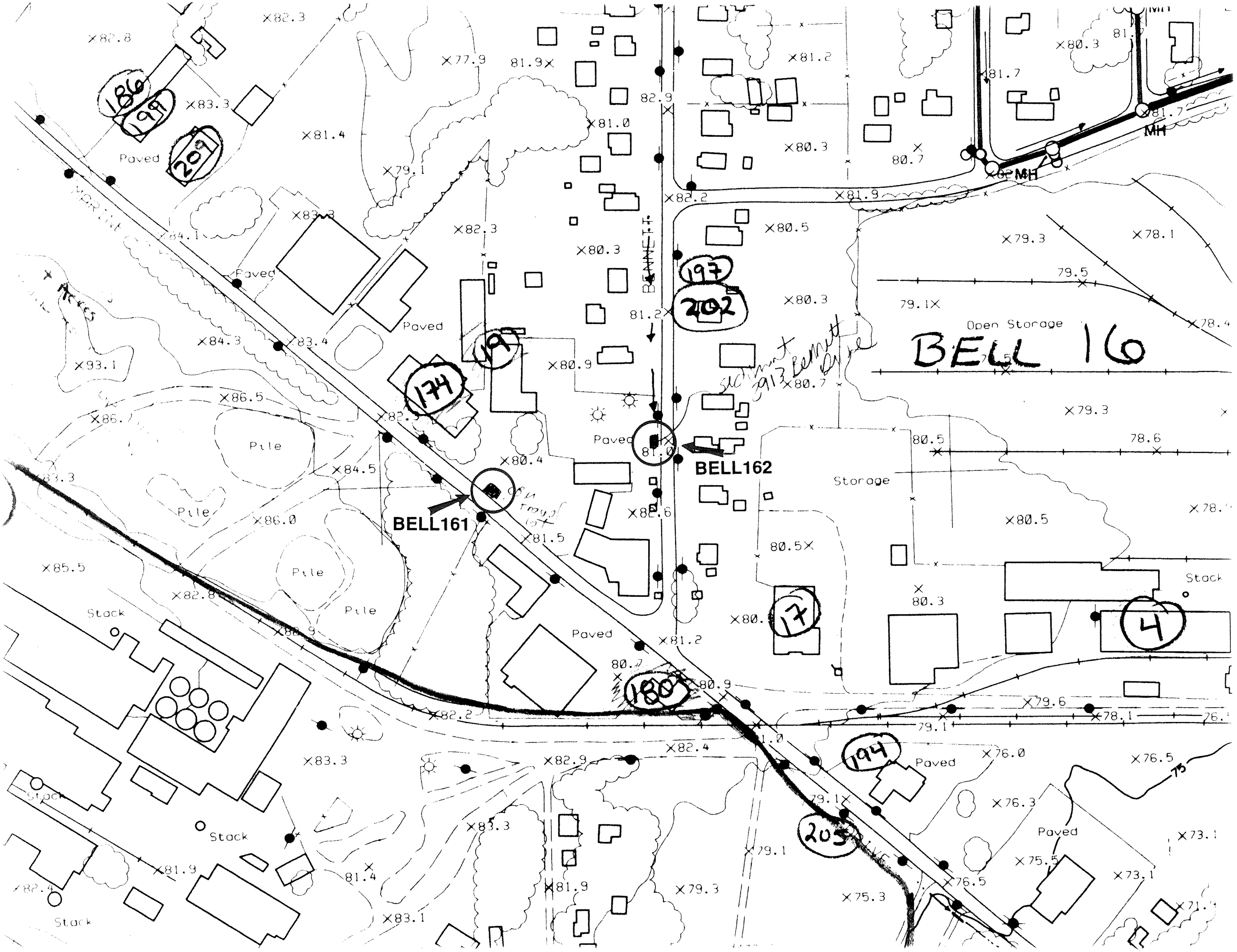

BELLINGHAM HARBOR
Mercator Projection
Scale 1:20,000
Nautical Miles
Yards
PLANE COORDINATE GRIDE
(based on NAD 1927)
Washington State Grid, north zone, is indicated by dashed ticks at 5000 foot intervals. The last 3 digits are omitted.
122° 30'
31'
46'
45'
48°
STACK
STACK
BN RR
Pipeline
Foul
Squalicum Creek
SPIRE
Dols
Piles
Fl R 6s 17ft 5M
Squalicum Creek Waterway
Fl R 4s 12ft 5M "2"
Fl G 4sec 17ft 6M "1"
Oc R 24ft 7M "2" HORN (Bl 15s)
Log boom Fl G 4sec
Snags
Waterway
BELL31
Q G 41ft
INNER REACH
Dolphins
BELL30
I & J Street
(see tabulation)
Fl G 2.5sec 15ft "1"
MIDDLE REACH
Log booms
Log Storage Area
Whatcom Creek Waterway
OUTER REACH
Fl 6s 15ft 7M
Rep dredged to 20ft 1966
RED SEC
GENERAL ANCHORAGE
110.230 (see note A)
BELLINGHAM BAY
(RANGE 45°12')
MEASURED 1 NAUTICAL MILE COURSE 37°06' TRUE
W Or Qk Fl Priv maintd
Starr Rock
Ruins
Hosp
Snag
gy M


WHATCOM CREEK
WHAT01
WHAT02
3-10'X10'
BOX CULVERTS
3-8'X8'
BOX CULVERTS
3-10'X12'
BOX CULVERTS
MH-NF
MH-IN
TOSS
MARITIME HERITAGE CENTER
MH
50
27"
15"
12"
8"
18"
30"
24"
21"


BELL091
STATE STREET
GARDEN
HIGH
Paved
TO SS
MH
pass. ss
pos. smoke results


BELL092
BELL093
ABANDONED
TOSS
MH
SB
2
10
11
21
31
32
41
42
43
44
46
49
50
52
55
58
9
100
160
BELL 09


BELL132
BELL131
MH
Paved
Storage
Substation
Pile
PLUG
TO SS
LD
SYST, 1
NF
HOLLY
STREET
5'X8'
TUNNEL
10"
8"
12"
15"
18"
21"
24"
50
25


BELL 16
BELL162
BELL161
Open Storage
Storage
Paved
Pile
Stack
MH

APPENDIX 2

LABORATORY CASE NARRATIVES

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

Data Review
March 26, 1993

Project: **Bremerton/Bellingham Storm Drains**

Samples: 078156 through 078177

Laboratory: Soil Technology J-339

By: Karin Feddersen KF

Case Summary

The review is for sediment grain size using Puget Sound Estuary Program (P.S.E.P.) protocol.

These samples were received at the Manchester Environmental Laboratory on March 31, 1993. They were transported to Soil Technology on April 5, 1993 for analysis.

These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness. The results are acceptable for use as reported.

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

Data Review
June 14, 1993

Project: **Bremerton/Bellingham Storm Drains**

Samples: 228180, 228181, 228182, 228183, 228184, 228185, 228190, 228191, 228192, 228193, 228194, 228196, 228197

Laboratory: Soil Technology J-369

By: Karin Feddersen KF

Case Summary

The review is for sediment grain size using Puget Sound Estuary Program (P.S.E.P.) protocol.

These samples were received at the Manchester Environmental Laboratory on May 27, 1993. They were transported to Soil Technology on May 27, 1993 for analysis.

These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness. The results are acceptable for use as reported.

SOIL TECHNOLOGY
SPECIALIZING IN PHYSICAL SOIL TESTING
7460 N.E. Day Road West
Bainbridge Island, WA 98110
(206) 842-9687 Fax 842-9014

LETTER OF TRANSMITTAL

TO: **Wa. State Dept. of Ecology**
7411 Beach Drive East
Port Orchard, WA 98366-8204

DATE: 06-07-93
JOB NO: J-369

ATTENTION: **Karin Feddersen**

SUBJECT: **Bremerton / Bellingham Storm Drains**

REFERENCE: **Sample ID No. 228180 through 228185, 228190 through 228194, 228196 and 228197**

We are sending the following items:

Date	Copies	Description
06-07-93	2	Sediment Grain Size Distribution (Page 1 through 3)
06-07-93	1	Chain of Custody Records
06-07-93	1	Bench Sheets

These are transmitted for your use.

Remarks: Samples were tested in general accordance with Puget Sound Estuary Protocol (Conventional Sediment Variables Particle Size March 1986). Values reported are "apparent" particle size as organic material is included in the analysis. Please call if you have any questions regarding this submittal or presentation of the data.

Best Regards,
SOIL TECHNOLOGY, INC.

Richard G. Sheets,
Vice President

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 871-8860 • SCAN 871-8860

May 27, 1993

TO: Project Officer

FROM: David A Thomson

SUBJECT: Quality Assurance memo for the Bremerton/Bellingham Storm Drains TOC Results

SAMPLE RECEIPT

The samples from the Bremerton/Bellingham Storm Drains were received by the Manchester Laboratory on March 31, 1993 in good condition. The analyses for these samples were subsequently contracted to Analytical Resources Inc. The samples were run using the Puget Sound Estuary Program (PSEP1986) for TOC.

HOLDING TIMES

All analyses were performed within 30 days of sample collection.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes.

PRECISION DATA

Five samples were run in duplicate to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the +/- 10% window for duplicate analysis.

SPIKED SAMPLE ANALYSIS

Spike and duplicate spike analysis were performed on sample number 148156 and 148167. Sample 148156 had spike recoveries of 70% and 57%. Sample 148167 had spike recoveries of 210% and 149%. This could indicate that the samples are very inhomogeneous. All results should be regarded as estimates.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS analyses were within the windows established for TOC.

SUMMARY

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

Please call David A Thomson at SCAN 871-8822 to further discuss this project.

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

May 6, 1993

Subject: Bremerton/ Bellingham Storm Drains

Samples: 93 - 148165 to -148172

Case No. DOE-689Y

Officer: James Cubbage

By: Dickey D. Huntamer
Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile soil samples were Soxhlet extracted with acetone following the Manchester modification of the EPA CLP and SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

All sample and extraction holding times were within the recommended limits.

BLANKS:

Low levels of some target compounds were detected in the laboratory blanks. The EPA five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

The normal Manchester Laboratory surrogates were added to the sample prior to extraction. All surrogate spike recoveries were within acceptable QC limits.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Matrix spike recoveries were outside acceptable limits for hexachloroethane, benzoic acid, 4-chloroaniline, 3-nitroaniline, 4-nitroaniline. The "J" data qualifier was added to the results for these compounds in sample 93-148168. One other compound hexachlorocyclopentadiene had low recoveries and the data was rejected, "REJ" as unusable.

ANALYTICAL COMMENTS:

No special analytical problems were encountered in the semivolatile analyses and the data is acceptable for use as qualified.

DATA QUALIFIER CODES:

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are unusable for all purposes.
EXP	-	The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
E	-	This qualifier is used when the concentration of the associated value exceeds the known calibration range.
*	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

MANCHESTER ENVIRONMENTAL LABORATORY

7411 Beach Drive E , Port Orchard Washington 98366

CASE NARRATIVE

July 28, 1993

Subject: Bremerton/Bellingham Storm Drains

Samples: 93 - 228180 to -228185, -228190 to -228194, -228196 and -228197

Case No. DOE-760Y

Officer: James Cubbage

By: Dickey D. Huntamer
Organics Analysis Unit

SEMIVOLATILE ORGANICS

ANALYTICAL METHODS:

The semivolatile soil samples were Soxhlet extracted with acetone following the Manchester modification of the EPA SW 846 8270 procedure with capillary GC/MS analysis of the sample extracts. Normal QA/QC procedures were performed with the analyses.

HOLDING TIMES:

All sample and extraction holding times were within the recommended limits.

BLANKS:

Low levels of some target compounds were detected in the laboratory blanks. The EPA five times rule was applied to all target compounds which were found in the blank. Compounds that were found in the sample and in the blank were considered real and not the result of contamination if the levels in the sample are greater than or equal to five times the amount of compounds in the associated method blank.

SURROGATES:

The normal surrogates compounds were added to the sample prior to extraction. All surrogate spike recoveries were within acceptable QC limits except for zero percent recovery for d10-pyrene in sample 93-228194 and 9.2% recovery for d4-1,2-dichlorobenzene. Since all of the other surrogates were okay no additional qualifiers were added to the results for -228194.

MATRIX SPIKE AND MATRIX SPIKE DUPLICATE:

Two sets of matrix spikes were analyzed with these samples. One set using sample, -228181 and the second set using sample, -228192. Matrix recoveries or Relative Percent Differences (RPD) were outside limits for some compounds. The results for those compounds in samples -228181 and -228192 were given the "J" data qualifier.

SPECIAL ANALYTICAL PROBLEMS:

No special analytical problems were encountered in the semivolatile analyses.

DATA QUALIFIER CODES:

U	-	The analyte was not detected at or above the reported value.
J	-	The analyte was positively identified. The associated numerical value is an estimate.
UJ	-	The analyte was not detected at or above the reported estimated result.
REJ	-	The data are unusable for all purposes.
EXP	-	The result is equal to the number before EXP times 10 to the power of the number after EXP. As an example 3EXP6 equals 3×10^6.
NAF	-	Not analyzed for.
N	-	For organic analytes there is evidence the analyte is present in this sample.
NJ	-	There is evidence that the analyte is present. The associated numerical result is an estimate.
E	-	This qualifier is used when the concentration of the associated value exceeds the known calibration range.
*	-	The analyte was present in the sample. (Visual Aid to locate detected compound on report sheet.)

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 895-4737 • SCAN 744-4737

May 10, 1993

TO: Jim Cubbage

FROM: Bill Kammin, Environmental_Lab_Director BK

SUBJECT: Metals Quality Assurance memo for the Bremerton/Bellingham Storm Drains Project

SAMPLE INFORMATION

These samples from the Bremerton/Bellingham Storm Drains Project were received by the Manchester Laboratory on 3/31/93 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes, with the following exception: copper. Sample results less than 10 times the level of copper in the procedural blank are qualified with B.

SPIKED SAMPLE ANALYSES

Spike and duplicate spike sample analyses were performed on this data set. All spike recoveries were within the CLP acceptance limits of +/- 25%, with the following exception: silver. Silver results are qualified with J, denoting estimated values.

PRECISION DATA

The results of the spike and duplicate spike samples were used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the 20% CLP acceptance window for duplicate analysis, with the following exception: silver.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS analyses were within the windows established for each parameter, with the following exception: silver.

SERIAL DILUTION ANALYSES

Serial dilution is used in ICP analyses to examine sample results for potential interferences. The serial dilution results for this sample set met CLP specifications, with the following exception: zinc. Zinc results are qualified with E, denoting possible sample based interferences.

SUMMARY

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

WRK:wrk

STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
MANCHESTER ENVIRONMENTAL LABORATORY
7411 Beach Drive East • Port Orchard, Washington 98366-8204 • (206) 895-4737 • SCAN 744-4737

June 30, 1993

TO: Jim Cubbage

FROM: Bill Kammin, Environmental_Lab_Director

SUBJECT: Metals Quality Assurance memo for the Bremerton/Bellingham Storm Drains Project

SAMPLE INFORMATION

The samples from the Bremerton/Bellingham Storm Drains project were received by the Manchester Laboratory on 5/27/93 in good condition.

HOLDING TIMES

All analyses were performed within the USEPA Contract Laboratory Program (CLP) holding times for metals analysis (28 days for mercury, 180 days for all other metals).

INSTRUMENT CALIBRATION

Instrument calibration was performed before each analytical run and checked by initial calibration verification standards and blanks. Continuing calibration standards and blanks were analyzed at a frequency of 10% during the run and again at the end of the analytical run. All initial and continuing calibration verification standards were within the relevant USEPA (CLP) control limits. AA calibration gave a correlation coefficient (r) of 0.995 or greater, also meeting CLP calibration requirements.

PROCEDURAL BLANKS

The procedural blanks associated with these samples showed no analytically significant levels of analytes.

SPIKED SAMPLE ANALYSES

Spike and duplicate spike sample analyses were performed on this data set. All spike recoveries were within the CLP acceptance limits of +/- 25%, with the following exceptions: copper, zinc, and arsenic. For copper and zinc, sample levels were greater than spiking levels, resulting in low recoveries. Copper and zinc results were qualified

with N. For arsenic, one spike recovery was slightly low at 72%. Arsenic results are qualified with N or J, depending on sample levels.

PRECISION DATA

The results of the spike and duplicate spike samples were used to evaluate precision on this sample set. The Relative Percent Difference (RPD) for all analytes was within the 20% CLP acceptance window for duplicate analysis.

LABORATORY CONTROL SAMPLE (LCS) ANALYSES

LCS analyses were within the windows established for each parameter.

SUMMARY

The data generated by the analysis of these samples can be used noting the data qualifications discussed in this memo.

Please call Bill Kammin at SCAN 206-871-8801 to further discuss this project.

WRK:wrk

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

June 8, 1993

Project: **Bremerton/Bellingham Storm Drains**

Samples: 148156, 148157, 148158, 148159, 148160, 148165, 148166, 148167, 148168, 148169, 148170, 148171, 148172

Laboratory: Analytical Resources Inc. D434

By: Karin Feddersen KF

Case Summary

These samples were received at the Manchester Environmental Laboratory on March 31, 1993, and transported to Analytical Resources, Inc. on April 5, 1993 for Pesticides/PCB's and Chlorinated Phenols analysis.

These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness.

There is no need to assimilate the "dilution factor" or "sample wt/vol" into the final values reported; these calculations have already been figured into the reported values.

DATA QUALIFIER DEFINITIONS

U - The analyte was not detected at or above the reported result.

UJ - The analyte was not detected at or above the reported estimated result.

J - The associated numerical result is an estimated quantity.

Pesticides/PCB's

Holding Times:

These samples were extracted and analyzed within the SW-846 recommended holding times.

Method Blank:

No target analytes were detected in the method blank.

Initial Calibration:

The initial calibration % Relative Standard Deviations were within the maximum of 20%.

Continuing Calibrations:

The percent deviations between the initial and continuing calibration standards were within the maximum of 25%.

Matrix Spikes (MS/MSD):

Matrix spike recovery and precision data are reasonable, acceptable, and within advisory QC limits.

Surrogates:

Surrogate recoveries for these samples, the matrix spikes, and the associated method blank are reasonable, acceptable, and within advisory QC limits.

Sample Data:

This data is acceptable for use without the need for additional data qualifiers.
The "X" qualifier is used by ARI to indicate that the associated result was derived from a response that exceeded the calibration range, and a dilution analysis was required. This "X" has been replaced by a "J" qualifier to indicate an estimated value. Use the dilution analyses for samples 108245 and 108246 for the Aldrin, Endosulfan I and II, Dieldrin, and 4,4'-DDT results; for all the other analytes use the undiluted analyses.

Chlorinated Phenols

Holding Times:

These samples were extracted and analyzed within the SW-846 recommended holding time.

Method Blank:

No target analytes were detected in the method blank.

Initial Calibration:

The initial calibration % Relative Standard Deviations were within the maximum of 20%.

Blank Spikes:

Blank spike recoveries are below QC limits. No explanation has been found for this anomaly. The spiking solution concentration was tested and found to be correct. The low recoveries for the spike blanks bring the validity of the data into question. The results indicate low analyte recoveries due to extraction/analysis inefficiencies. The samples most likely behaved in a similar manner, and are to be considered biased low. All detected analytes in these samples have therefore been qualified with a "J", and non-detected analytes been qualified with a "UJ".

Surrogates:

QC limits have yet to be established by ARI for this method. All sample surrogate recoveries appear reasonable and acceptable.

Sample Data:

These results are to be used with caution.

State of Washington Department of Ecology
Manchester Environmental Laboratory
7411 Beach Dr. East Port Orchard WA. 98366

July 21, 1993

Project: **Bremerton/Bellingham Storm Drains**

Samples: 228180, 228181, 228182, 228183, 228184, 228185, 228190, 228191, 228192, 228193, 228194, 228196, 228197

Laboratory: Analytical Resources Inc. D932

By: Karin Feddersen KF

Case Summary

These samples were received at the Manchester Environmental Laboratory on May 27, 1993, and transported to Analytical Resources, Inc. on May 27, 1993 for VOC, Pesticides/PCB and Chlorinated Phenols analysis.

These analyses were reviewed for qualitative and quantitative accuracy, validity, and usefulness.

There is no need to assimilate the "dilution factor" or "sample wt/vol" into the final values reported; these calculations have already been figured into the reported values.

DATA QUALIFIER DEFINITIONS

U - The analyte was not detected at or above the reported result.

UJ - The analyte was not detected at or above the reported estimated result.

J - The associated numerical result is an estimated quantity.

NJ or JN - The analyte was tentatively identified. The associated numerical result is an estimate.

REJ - The data is unusable for all purposes.

Volatiles

Holding Times:

These samples were analyzed within the SW-846 recommended holding time.

Method Blank:

Acetone was detected in all of the method blanks. Acetone was also detected in several of the samples. Where the on-column amount of Acetone in the sample exceeded the on-column amount of Acetone in the corresponding method blank by more than ten (10) times, Acetone is most likely native to the sample, and no qualification is warranted. Where the on-column amount of Acetone in the samples is less than ten (10) times the on-column amount of Acetone in the corresponding method blank, the Acetone detected in these samples is most likely due to laboratory contamination and not native to the samples. Therefore the results for Acetone in these sample have been qualified with a "U" to indicate that Acetone was not detected at or above the suspected laboratory contamination level.

GC/MS Tuning and Calibration:

Calibration against Bromofluorobenzene (BFB) is acceptable for the initial calibration, continuing calibration, and all associated sample analyses.

Initial Calibration:

The initial calibration met the minimum response criteria for the average relative responses. The % Relative Standard Deviations were within the maximum of 30%.

Continuing Calibration:

These samples were analyzed on four separate days. The average relative response factors for all target analytes were above the minimums, and the percent deviations between the initial and continuing calibration standards were within the maximum of 25%, with several exceptions for each day. Positive results for these analytes have been qualified with a "J", and non-detected results have been qualified with a "UJ" in the corresponding samples and method blanks.

Matrix Spikes (MS/MSD):

Matrix spike recovery and precision data are reasonable, acceptable, and within QC limits with one exception. The toluene recovery in 228183MS was slightly above the QC limit for this analyte. The toluene recovery was acceptable for 228183 MSD. No qualification of the data was warranted.

Surrogates:

All surrogate recoveries for these samples and the associated method blank are reasonable, acceptable, and within QC limits with several exceptions. D8-Toluene recovery was low in sample 228185 and the matrix spikes performed on this sample. Sample 228185 was reanalyzed, and d8-Toluene exhibited acceptable recovery. No qualification of the results was warranted.

Sample results:

One of the internal standards (d5-Chlorobenzene) in sample 228184 fell below the QC limits, affecting quantitation for analytes in this sample which use this internal standard for quantitation. Positive results for these analytes in sample 228184 have been qualified with a "J", and non-detected analytes have been qualified with a "UJ".
The amount of Toluene detected in the original analyses of samples 228184, 228191, 228194, and 228197 exceeded the calibration of the instrument. Toluene results for these sample analyses have been qualified with "REJ". Use the Toluene results from the medium analyses and reanalyses of sample 228184, 228191, 228194, and 228197. Use the original results for all other analytes.
This data is acceptable for use as amended.

Pesticides/PCB's

Holding Times:

The waters were extracted and analyzed within the SW-846 recommended holding times. The soils were extracted one day past the SW-846 recommended holding time. These soil samples were stored in the proper containers at the proper temperature, therefore, extraction one day beyond the recommended holding time should not have a significant effect upon the results. All extracts were analyzed within the recommended holding time of forty days from the date of extraction.

Method Blank:

No target analytes were detected in either method blank.

Initial Calibration:

The initial calibration % Relative Standard Deviations were within the maximum of 20% with several exceptions which did not affect the results.

Continuing Calibrations:

The percent deviations between the initial and continuing calibration standards were within the maximum of 25% with one exception which did not affect the results.

Matrix Spikes (MS/MSD):

Matrix spike recovery and precision data are reasonable, acceptable, and within advisory QC limits.

Surrogates:

Surrogate recoveries for these samples, the matrix spikes, and the associated method blank are reasonable, acceptable, and within advisory QC limits with several exceptions. Matrix effects due to the presence of Arochlor 1254 most likely interfered with an accurate quantitation of Decachlorobiphenyl (DCB) in sample 228180 and in the matrix spikes performed on this sample (228180MS and 228180MSD). No qualification of the data was warranted for these analyses. DCB recovery in sample 228197 was low on one column, and Tetrachloro-m-xylene (TCX) recovery was low in samples 228184, 228191, and 228194. Since quantitation was sufficient for the other column, non-detected compounds in these samples were unaffected. Detected compounds in these samples which demonstrated a discrepancy in quantitation between the two columns have been qualified with a "J".

Sample Data:

The DDE detected in the matrix spikes performed on sample 228180, (228180MS and 228180MSD), is most likely a degradation product of the DDT added as a spike to the sample for QC purposes, and is not native to the sample.
This data is acceptable for use as amended.

Chlorinated Phenols

Holding Times:

These samples were extracted and analyzed six days past the SW-846 recommended holding time. Sample 228196 was re-extracted nine days past the SW-846 recommended holding time. The samples were stored in the proper containers at the proper temperature, therefore, analysis beyond the recommended holding time should not have a significant effect upon the results. The extracts were analyzed within the recommended holding time of forty days from the date of extraction.

Method Blank:

No target analytes were detected in either method blank.

Initial Calibration:

The initial calibration % Relative Standard Deviations were within the maximum of 20%.

Continuing Calibrations:

The percent deviations between the initial and continuing calibration standards were within the maximum of 25%.

Blank Spike:

Blank spike recoveries are reasonable, acceptable and within QC limits.

Surrogates:

Soil QC limits have yet to be established by ARI for this method. All sample surrogate recoveries appear reasonable and acceptable with one exception. Sample 228196 exhibited a low surrogate recovery. All results for the original analysis of sample 228196 have been qualified with "REJ". This sample was re-extracted and reanalyzed with slightly improved recovery on June 17,1993. No qualification or rejection of the results from this reanalysis was warranted.

Sample Data:

Use the results from the reanalysis dated June 17, 1993 for sample 228186.
These results are acceptable for use as amended.

DATA REVIEW

BY: Margaret Stinson MDS

FOR: Bremerton Storm Drains
Sample Numbers 14-8165, 14-8166

DATE: May 12, 1993

Parametrix Laboratory has submitted the attached results of bioassays using Microtox and *Hyalella azteca* on two samples collected from Bremerton Storm Drains. Results of the tests were as follows:

MICROTOX

The samples were extracted using deionized water, and analyzed using PSEP methods. The laboratory reported the results as Percent Light Change at the highest concentration tested (45%); as part of the data review, the EC50 was also calculated and is reported here.

	% Light Change	EC50
14-8165	24%	>100%
14-8166	7%	>100%

Hyalella azteca

Survival in the *Hyalella azteca* test resulted in the following survival for each of the samples:

	Average % Survival
14-8165	56%
14-8166	86%

The response was statistically different from the control (94% survival) in sample 14-8165. The report indicates the presence of an oily sheen on the surface of the overlying water in the test chambers, and difficulty in maintaining adequate dissolved oxygen (DO) in the first

days of testing that sample. It is uncertain whether chemical toxicity or oxygen demand of the sediment (or both) was responsible for poor survival in testing.

These analyses were supported by appropriate QA/QC for each test, including positive and negative controls. Chemical analyses of test solutions showed them to be appropriate for the health of test organisms for the parameters analyzed, except as noted.