RI

DOCUMENTATION OF ENVIRONMENTAL INDICATOR DETERMINATION

Interim Final 2/5/99

RCRA Corrective Action
Environmental Indicator (EI) RCRIS code (CA750)

Migration of Contaminated Groundwater Under Control

Facility Name: **Philip Services Corporation - Northland Environmental Facility**
Facility Address: **275 Allens Avenue, Providence, RI 02908**
Facility EPA ID #: **RID 040098352**

1. Has **all** available relevant/significant information on known and reasonably suspected releases to the groundwater media, subject to RCRA Corrective Action (e.g., from Solid Waste Management Units (SWMU), Regulated Units (RU), and Areas of Concern (AOC)), been **considered** in this EI determination?

__X__ If yes - check here and continue with #2 below.

_____ If no - re-evaluate existing data, or

_____ if data are not available, skip to #8 and enter "IN" (more information needed) status code.

BACKGROUND

Definition of Environmental Indicators (for the RCRA Corrective Action)

Environmental Indicators (EI) are measures being used by the RCRA Corrective Action program to go beyond programmatic activity measures (e.g., reports received and approved, etc.) to track changes in the quality of the environment. The two EI developed to-date indicate the quality of the environment in relation to current human exposures to contamination and the migration of contaminated groundwater. An EI for non-human (ecological) receptors is intended to be developed in the future.

Definition of "Migration of Contaminated Groundwater Under Control" EI

A positive "Migration of Contaminated Groundwater Under Control" EI determination ("YE" status code) indicates that the migration of "contaminated" groundwater has stabilized, and that monitoring will be conducted to confirm that contaminated groundwater remains within the original "area of contaminated groundwater" (for all groundwater "contamination" subject to RCRA corrective action at or from the identified facility (i.e., site-wide)).

Relationship of EI to Final Remedies

While Final remedies remain the long-term objective of the RCRA Corrective Action program the EI are near-term objectives which are currently being used as Program measures for the Government Performance and Results Act of 1993, GPRA). The "Migration of Contaminated Groundwater Under Control" EI pertains ONLY to the physical migration (i.e., further spread) of contaminated ground water and contaminants within groundwater (e.g., non-aqueous phase liquids or NAPLs). Achieving this EI does not substitute for achieving other stabilization or final remedy requirements and expectations associated with sources of contamination and the need to restore, wherever practicable, contaminated groundwater to be suitable for its designated current and future uses.

Duration / Applicability of EI Determinations

EI Determinations status codes should remain in RCRIS national database ONLY as long as they remain true (i.e., RCRIS status codes must be changed when the regulatory authorities become aware of contrary information).

2. Is **groundwater** known or reasonably suspected to be **"contaminated"**[1] above appropriately protective "levels" (i.e., applicable promulgated standards, as well as other appropriate standards, guidelines, guidance, or criteria) from releases subject to RCRA Corrective Action, anywhere at, or from, the facility?

__X__ If yes - continue after identifying key contaminants, citing appropriate "levels," and referencing supporting documentation.

_____ If no - skip to #8 and enter "YE" status code, after citing appropriate "levels," and referencing supporting documentation to demonstrate that groundwater is not "contaminated."

_____ If unknown - skip to #8 and enter "IN" status code.

Rationale and Reference(s):_**Key contaminant is Arsenic. This contaminant is found in ground water at levels above the National Recommended Water Quality Criteria at a point approximately 20-30 feet upgradient of the concrete rubble barrier wall which marks the edge of the Bay. Drinking water levels were not considered because the ground water (GW) is classified as GB which indicates it is not suitable for use as a current or potential source of drinking water and the same is true for the Narragansett Bay. The GW discharges into the Narragansett Bay. See the Subsurface Investigation Report - dated February 2000, and the ground water monitoring reports from 1995 to present.**

Footnotes:

[1]"Contamination" and "contaminated" describes media containing contaminants (in any form, NAPL and/or dissolved, vapors, or solids, that are subject to RCRA) in concentrations in excess of appropriate "levels" (appropriate for the protection of the groundwater resource and its beneficial uses).

3. Has the **migration** of contaminated groundwater **stabilized** (such that contaminated groundwater is expected to remain within "existing area of contaminated groundwater"[2] as defined by the monitoring locations designated at the time of this determination)?

__X__ If yes - continue, after presenting or referencing the physical evidence (e.g., groundwater sampling/measurement/migration barrier data) and rationale why contaminated groundwater is expected to remain within the (horizontal or vertical) dimensions of the "existing area of groundwater contamination"[2]).

_____ If no (contaminated groundwater is observed or expected to migrate beyond the designated locations defining the "existing area of groundwater contamination"[2]) - skip to #8 and enter "NO" status code, after providing an explanation.

_____ If unknown - skip to #8 and enter "IN" status code.

Rationale and Reference(s):_ **Since the facility is located along the Bay, the existing area of ground water contamination includes the facility and the discharge point into the Narragansett Bay. Contaminated GW at the facility property line discharges immediately into the Bay. Due to the nature of the arsenic contamination being a dissolved phase contaminant leached from on-site subsurface soils it is expected to remain in the current zone of contamination. The plume is not anticipated to be significantly denser than ambient groundwater, and it is an extremely short flow path to surface water with no opportunity for underflow and no downward flow gradient.**

[2] "existing area of contaminated groundwater" is an area (with horizontal and vertical dimensions) that has been verifiably demonstrated to contain all relevant groundwater contamination for this determination, and is defined by designated (monitoring) locations proximate to the outer perimeter of "contamination" that can and will be sampled/tested in the future to physically verify that all "contaminated" groundwater remains within this area, and that the further migration of "contaminated" groundwater is not occurring. Reasonable allowances in the proximity of the monitoring locations are permissible to incorporate formal remedy decisions (i.e., including public participation) allowing a limited area for natural attenuation.

4. Does "contaminated" groundwater **discharge** into **surface water** bodies?

__X__ If yes - continue after identifying potentially affected surface water bodies.

_____ If no - skip to #7 (and enter a "YE" status code in #8, if #7 = yes) after providing an explanation and/or referencing documentation supporting that groundwater "contamination" does not enter surface water bodies.

_____ If unknown - skip to #8 and enter "IN" status code.

Rationale and Reference(s):_**The facility groundwater discharges into the Narragansett Bay.**

5. Is the **discharge** of "contaminated" groundwater into surface water likely to be **"insignificant"** (i.e., the maximum concentration[3] of each contaminant discharging into surface water is less than 10 times their appropriate groundwater "level," and there are no other conditions (e.g., the nature, and number, of discharging contaminants, or environmental setting), which significantly increase the potential for unacceptable impacts to surface water, sediments, or eco-systems at these concentrations)?

_X_ If yes - skip to #7 (and enter "YE" status code in #8 if #7 = yes), after documenting: 1) the maximum known or reasonably suspected concentration[3] of key contaminants discharged above their groundwater "level," the value of the appropriate "level(s)," and if there is evidence that the concentrations are increasing; and 2) provide a statement of professional judgement/explanation (or reference documentation) supporting that the discharge of groundwater contaminants into the surface water is not anticipated to have unacceptable impacts to the receiving surface water, sediments, or eco-system.

____ If no - (the discharge of "contaminated" groundwater into surface water is potentially significant) - continue after documenting: 1) the maximum known or reasonably suspected concentration[3] of each contaminant discharged above its groundwater "level," the value of the appropriate "level(s)," and if there is evidence that the concentrations are increasing; and 2) for any contaminants discharging into surface water in concentrations[3] greater than 100 times their appropriate groundwater "levels," the estimated total amount (mass in kg/yr) of each of these contaminants that are being discharged (loaded) into the surface water body (at the time of the determination), and identify if there is evidence that the amount of discharging contaminants is increasing.

____ If unknown - enter "IN" status code in #8.

Rationale and Reference(s): **Arsenic is the only contaminant of concern. The most recent data (July 2000) on the discharge level of arsenic = .31mg/l and .30mg/l at well LFR-5 and LFR-6 (average of original and duplicate sample); the Water Quality Criteria for freshwater systems is .150mg/l for chronic and .340mg/l for acute; the Water Quality Criteria for saltwater systems is .036mg/l for chronic and .069mg/l for acute; there is no evidence that the concentrations are increasing. There is evidence that the levels are rapidly attenuating in the groundwater-surface water/sediment interaction zone. This is evidenced by arsenic concentrations in well MW-5 at 4.27mg/l which is 30 feet upgradient of wells LFR-5 and LFR-6 at .31 and .30mg/l which in turn are 10-15 feet upgradient of the Bay. Therefore, it is expected that the ultimate discharge levels are lower than those reported in LFR-5 and LFR-6. A further study is planned to confirm this point by taking groundwater samples from the banks at low tide.**

The width of the contaminated discharge is approximately 60 feet along a property line of approximately 320 feet, leaving 260 feet of non-contaminated groundwater. The Narragansett Bay is a freshwater/saltwater Bay with the facility located approximately at the mixing zone. The volume of water in the Bay is several orders of magnitude larger than the volume of contaminated discharge from the facility. The receiving body is tidal and gets flushed regularly. The surficial sediments in the area of the site have been shown to have arsenic concentrations between 10.1 and 11.8 mg/kg as shown in a recent Bay study conducted by John W. King under the sponsorship of the URI/NOAA Cooperative Marine Education and Research program. The Surface Water in that area of the Narragansett Bay is classified by the RI DEM as SB1(a) which designates seawater which may be impacted due to wastewater discharges.

Given this scenario, in my professional judgement the discharge of this single groundwater contaminant into the surface water is not anticipated to have unacceptable impacts to the receiving surface water, sediments, or eco-system.

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[3] As measured in groundwater prior to entry to the groundwater-surface water/sediment interaction (e.g., hyporheic) zone.

6. Can the **discharge** of "contaminated" groundwater into surface water be shown to be "**currently acceptable**" (i.e., not cause impacts to surface water, sediments or eco-systems that should not be allowed to continue until a final remedy decision can be made and implemented[4])?

_____ If yes - continue after either: 1) identifying the Final Remedy decision incorporating these conditions, or other site-specific criteria (developed for the protection of the site's surface water, sediments, and eco-systems), and referencing supporting documentation demonstrating that these criteria are not exceeded by the discharging groundwater; OR
2) providing or referencing an interim-assessment,[5] appropriate to the potential for impact, that shows the discharge of groundwater contaminants into the surface water is (in the opinion of a trained specialists, including ecologist) adequately protective of receiving surface water, sediments, and eco-systems, until such time when a full assessment and final remedy decision can be made. Factors which should be considered in the interim-assessment (where appropriate to help identify the impact associated with discharging groundwater) include: surface water body size, flow, use/classification/habitats and contaminant loading limits, other sources of surface water/sediment contamination, surface water and sediment sample results and comparisons to available and appropriate surface water and sediment "levels," as well as any other factors, such as effects on ecological receptors (e.g., via bio-assays/benthic surveys or site-specific ecological Risk Assessments), that the overseeing regulatory agency would deem appropriate for making the EI determination.

_____ If no - (the discharge of "contaminated" groundwater can not be shown to be "**currently acceptable**") - skip to #8 and enter "NO" status code, after documenting the currently unacceptable impacts to the surface water body, sediments, and/or eco-systems.

_____ If unknown - skip to 8 and enter "IN" status code.

Rationale and Reference(s): ~~The discharge of this GW into the Providence Harbor is adequately protective of the receiving surface water, sediments, and eco-systems based on the following factors:~~ F.B. 9-20-00

[4] Note, because areas of inflowing groundwater can be critical habitats (e.g., nurseries or thermal refugia) for many species, appropriate specialist (e.g., ecologist) should be included in management decisions that could eliminate these areas by significantly altering or reversing groundwater flow pathways near surface water bodies.

[5] The understanding of the impacts of contaminated groundwater discharges into surface water bodies is a rapidly developing field and reviewers are encouraged to look to the latest guidance for the appropriate methods and scale of demonstration to be reasonably certain that discharges are not causing currently unacceptable impacts to the surface waters, sediments or eco-systems.

7. Will groundwater **monitoring** / measurement data (and surface water/sediment/ecological data, as necessary) be collected in the future to verify that contaminated groundwater has remained within the horizontal (or vertical, as necessary) dimensions of the "existing area of contaminated groundwater?"

__X__ If yes - continue after providing or citing documentation for planned activities or future sampling/measurement events. Specifically identify the well/measurement locations which will be tested in the future to verify the expectation (identified in #3) that groundwater contamination will not be migrating horizontally (or vertically, as necessary) beyond the "existing area of groundwater contamination."

_____ If no - enter "NO" status code in #8.

_____ If unknown - enter "IN" status code in #8.

Rationale and Reference(s):_**The wells labeled MW-5, LFR-5, LFR-6, LFR-7 and possibly others will be monitored quarterly until a final remedy decision is made.**

8. Check the appropriate RCRIS status codes for the Migration of Contaminated Groundwater Under Control EI (event code CA750), and obtain Supervisor (or appropriate Manager) signature and date on the EI determination below (attach appropriate supporting documentation as well as a map of the facility).

__X__ YE - Yes, "Migration of Contaminated Groundwater Under Control" has been verified. Based on a review of the information contained in this EI determination, it has been determined that the "Migration of Contaminated Groundwater" is "Under Control" at the **Philip Services Corporation - Northland Environmental facility**, EPA ID # **RID040098352**, located at **275 Allens Avenue, Providence, RI 02908**. Specifically, this determination indicates that the migration of "contaminated" groundwater is under control, and that monitoring will be conducted to confirm that contaminated groundwater remains within the "existing area of contaminated groundwater" This determination will be re-evaluated when the Agency becomes aware of significant changes at the facility.

_____ NO - Unacceptable migration of contaminated groundwater is observed or expected.

_____ IN - More information is needed to make a determination.

Completed by (signature) Frank Battaglia Date 9-20-00
Frank Battaglia
Environmental Engineer

Supervisor (signature) [signature] Date 9/26/00
Matthew Hoagland
Chief, RCRA Corrective Action Section
EPA - New England

Locations where References may be found:

References are located in the facility files at the EPA - New England record center.

Contact telephone and e-mail numbers

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	StationNum	StationName	lat	lon	WaterDep_ft	SedDep1_meters	SedDep2_meters	SampleID	DecimalDate
	1	Allen_Harbor	41.62430	-71.41352	13.7	0.00	0.02	BP97-01	1997.4986301363
	2	Potowomut_Cove	41.65568	-71.41874	5.4	0.00	0.02	BP97-02	1997.4986301363
	3	Brush_Neck_Cove	41.69464	-71.40712	6.7	0.00	0.02	BP97-03	1997.4986301363
	4	Warwick_Cove	41.69627	-71.38661	2.0	0.00	0.02	BP97-04	1997.4986301363
	5	Greenwich_Cove	41.65234	-71.45027	6.1	0.00	0.02	BP97-05	1997.4986301363
	6	Old_Station_17	41.68144	-71.42577	12.1	0.00	0.02	BP97-06	1997.4986301363
	7	Mid_Greenwich_Bay	41.67709	-71.42344	14.7	0.00	0.02	BP97-07	1997.4986301363
	8	Wickford_Harbor	41.56933	-71.44676	8.6	0.00	0.02	BP97-08	1997.5753424764
	9	Old_Station_19	41.56954	-71.40151	25.3	0.00	0.02	BP97-09	1997.5753424764
	10	Old_Station_20	41.51538	-71.40022	65.7	0.00	0.02	BP97-10	1997.5753424764
	11	Old_Station_15	41.49451	-71.33009	44.7	0.00	0.02	BP97-11	1997.5753424764
	12	Old_Station_12	41.60936	-71.29396	74.0	0.00	0.02	BP97-12	1997.5753424764
	13	Hog_Island	41.62187	-71.28866	50.0	0.00	0.02	BP97-13	1997.5753424764
	14	Bristol_Harbor	41.66466	-71.28314	19.0	0.00	0.02	BP97-14	1997.5753424764
	15	Ohio_Ledge	41.69437	-71.34198	21.3	0.00	0.02	BP97-15	1997.5753424764
	16	Old_Station_7	41.70891	-71.33533	42.7	0.00	0.02	BP97-16	1997.5753424764
	17	Conimicut_Point	41.72782	-71.36696	22.3	0.00	0.02	BP97-17	1997.5753424764
	18	Old_Station_18	41.63858	-71.37934	24.0	0.00	0.02	BP97-18	1997.5753424764
	19	Calf_Pasture_Point	41.62913	-71.39025	26.3	0.00	0.02	BP97-19	1997.5753424764
7.7	20	Sabin_Point	41.75631	-71.36791	14.5	0.00	0.02	BP97-20	1997.5972602963
	21	Bullock_Cove	41.75278	-71.35576	4.8	0.00	0.02	BP97-21	1997.5972602963
10.1	22	Fields_Point – south site	41.78173	-71.37964	9.8	0.00	0.02	BP97-22	1997.5972602963
11.8	23	Fox_Point – north	41.81183	-71.39653	34.1	0.00	0.02	BP97-23	1997.5972602963
11.5	24	State_Pier_N._S._R.	41.86972	-71.38121	7.8	0.00	0.02	BP97-24	1997.5972602963
10.8	25	Bucklin_Point	41.85766	-71.37574	3.0	0.00	0.02	BP97-25	1997.5972602963
11.6	26	Pawtuxet_Cove	41.75516	-71.38358	6.6	0.00	0.02	BP97-26	1997.5972602963
	27	Apponaug_Cove	41.69051	-71.44364	6.1	0.00	0.02	BP97-27	1997.8301370144
	28	Kickamuit_River	41.71238	-71.24951	11.3	0.00	0.02	BP97-28	1998.1123287678
	29	Cole_River	41.73114	-71.21619	7.4	0.00	0.02	BP97-29	1998.1123287678
	30	Lee_River	41.73419	-71.19018	2.1	0.00	0.02	BP97-30	1998.1123287678
	31	Brayton_River	41.70846	-71.18586	26.0	0.00	0.02	BP97-31	1998.1123287678
	32	Spar_Island	41.69034	-71.20724	17.2	0.00	0.02	BP97-32	1998.1123287678
	33	Common_Fence_Point	41.65366	-71.22739	22.2	0.00	0.02	BP97-33	1998.1123287678
	34	Quonset_Piers_1-2	41.61285	-71.40424	35.7	0.00	0.02	BP97-34	1998.1698630154
	35	Quonset_Point	41.60590	-71.39572	38.6	0.00	0.02	BP97-35	1998.1698630154
	36	Quonset_Point	41.60464	-71.41151	21.9	0.00	0.02	BP97-36	1998.1698630154
	37	Shaws_Marina	41.81417	-71.11542	2.8	0.00	0.02	BP97-37	1998.1945205480
	38	TauntonR.S.of_M.Cv.	41.80441	-71.12086	10.7	0.00	0.02	BP97-38	1998.1945205480
	39	TauntonR.PierceePt.	41.79214	-71.12019	10.2	0.00	0.02	BP97-39	1998.1945205480
	40	Taunton_River	41.77023	-71.11586	2.7	0.00	0.02	BP97-40	1998.1945205480
	41	Somerset_Breeds_Cv	41.73301	-71.15045	5.0	0.00	0.02	BP97-41	1998.1945205480
	42	Seekonk_River	41.83767	-71.37797	2.9	0.00	0.02	BP98-42	1998.7068493366
	43	Barrington_River	41.74106	-71.30545	1.0	0.00	0.02	BP98-43	1998.8849315047
	44	Briggs_Marsh_Pond	41.47832	-71.16430	3.0	0.00	0.02	BriggsPnd	1998.6904109716
	45	Tunipers_Pond	41.49698	-71.13917	8.1	0.00	0.02	TunipersP	1998.6904109716
	46	Nannaquaket_Pond	41.61064	-71.20000	6.3	0.00	0.02	Nannaquak	1998.6904109716
	47	Quicksand_Pond	41.51068	-71.13140	7.0	0.00	0.02	Quicksand	1998.6904109716
	48	Hundred_Acre_Cove4	41.76092	-71.31087	4.7	0.00	0.02	HundredAC	1998.8849315047
	36	Quonset_Point	41.60397	-71.41157	21.5	0.00	0.10	BP97-36C1	1998.1698630154
	36	Quonset_Point	41.60397	-71.41157	21.5	0.10	0.20	BP97-36C1	1998.1698630154
	36	Quonset_Point	41.60397	-71.41157	21.5	0.20	0.30	BP97-36C1	1998.1698630154

36	Quonset_Point	41.60397	-71.41157	21.5	0.30	0.40	BP97-36C1	1998.1698630154
36	Quonset_Point	41.60397	-71.41157	21.5	0.40	0.50	BP97-36C1	1998.1698630154
36	Quonset_Point	41.60397	-71.41157	21.5	0.50	0.60	BP97-36C1	1998.1698630154
36	Quonset_Point	41.60397	-71.41157	21.5	0.60	0.70	BP97-36C1	1998.1698630154
36	Quonset_Point	41.60397	-71.41157	21.5	0.70	0.80	BP97-36C1	1998.1698630154
36	Quonset_Point	41.60397	-71.41157	21.5	0.80	0.90	BP97-36C1	1998.1698630154
36	Quonset_Point	41.60397	-71.41157	21.5	0.90	1.00	BP97-36C1	1998.1698630154
36	Quonset_Point	41.60397	-71.41157	21.5	1.00	1.10	BP97-36C1	1998.1698630154
42	Seekonk_River	41.83763	-71.37767	2.3	0.02	0.04	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.06	0.08	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.10	0.12	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.16	0.18	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.24	0.26	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.32	0.34	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.38	0.40	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.48	0.50	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.58	0.60	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.68	0.70	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.78	0.80	BP98-42C2	1998.7068493366
42	Seekonk_River	41.83763	-71.37767	2.3	0.88	0.90	BP98-42C2	1998.7068493366
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.02	0.04	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.06	0.08	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.10	0.12	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.20	0.22	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.30	0.32	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.40	0.42	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.50	0.52	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.60	0.62	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.70	0.72	BP97-27C2	1997.8301370144
27	Apponaug_Cove	41.69052	-71.44370	6.1	0.80	0.82	BP97-27C2	1997.8301370144

ARSENIC
8.2 = ERL = ug/g
70 = ERM

CONNIE CAREY RIDER
X7239

Trace Metal Contaminants in the Sediments of Narragansett Bay

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Grant No. NA77FE0493

URI No. 5-31634

Period: 9/1/97 – 11/30/98

December 31, 1998

This study was conducted under the sponsorship of the URI/NOAA Cooperative Marine Education and Research (CMER) Program.

Introduction

An extensive survey of contaminants in the sediments of Narragansett Bay was undertaken during 1988-1989 as part of the Narragansett Bay Project (NBP). However, the Quinn *et al.* (1992), King *et al.* (1995) NBP survey provided very limited coverage of Taunton River and Mt. Hope Bay (1 site). This study was undertaken to update and expand the coverage of the NBP study. We collected surface sediments (0-2 cm) from 43 Narragansett Bay stations and 5 coastal ponds, and 1 meter sediment cores from 3 Narragansett Bay stations. This study will provide an up-to-date database on contamination in coves, harbors, salt pond and critical nursery areas that were not well studied during the initial NBP study. Contaminants that were studied include nutrients (C, N), trace metals, and organic contaminants. In addition, sediment grain size was determined at all stations.

Materials and Methods

1) Field Collection: All samples were collected and processed by John King and his staff. Navigation was provided using a Trimble DGPS system that has 5 m accuracy. Station locations are listed in Table 1 and are shown in Figure 1. Surface samples were collected using a Smith-McIntyre grab sampler deployed from a 22′ pontoon boat. Three grabs were collected at each station and the 0-2 cm interval sampled using titanium scoops. Grain size and trace metal samples (200 cc total) were obtained from the individual grabs and the residual material (800 cc) from each of the three grabs was composited. Each

station composite sample was analyzed for nutrients, organic contaminants, and simultaneously extracted metals (SEM) and acid volatile sulfide (AVS). Three 10 cm diameter, one meter piston cores were collected at Apponaug Cove, Quonset Point, and the Seekonk River. Low-field magnetic susceptibility logs were done on each core and the susceptibility logs were used to determine the heterogeneity of sedimentation at the station, the approximate age of the core, and to select one core from each station for detailed study. Based on the susceptibility profiles, at least six intervals (usually 2 cm) were collected from the highest quality core from each of three stations and utilized for nutrient, trace metal, organic contaminant, and grain size analysis.

2) Trace Metals: The inorganic contaminants that were analyzed for this project are shown in Table 2. All concentrations are reported on a dry weight basis. In addition, we measured acid volatile sulfide (AVS) and simultaneously extracted metals (SEM; Cd, Cu, Ni, Pb, and Zn). Methods are described in King *et al.* (1995) and URI/SAIC (1995).

3) Other Analyses: Grain size and nutrient (C, N) were determined for all samples. Methods are described in King *et al.* (1995) and URI/SAIC (1995).

Results and Discussion

1) Surface Sediments: Figure 2 shows the concentrations of selected trace metal contaminants in the surface sediments (0-2 cm) of Narragansett Bay.

The effects range (ER) concentrations of Long *et al.* (1995) versus the spatial distribution for selected analyses are shown in Figures 2a–2e. Silver concentrations exceed ERM values in both the Seekonk and Providence Rivers and the Taunton River and in addition exceed ERL values at many locations in upper- and mid-Narragansett Bay (Fig. 2a). Lead concentrations exceed ERM values at Fox Point and in Greenwich Cove and exceed ERL values throughout upper- and mid-Narragansett Bay (Fig. 2b). Chromium concentrations exceed ERL values throughout upper- and mid-Narragansett Bay (Fig. 2c). Cadmium concentrations exceed ERL values only in the Seekonk and Providence Rivers and Brush Neck Cove (Fig. 2d). Arsenic concentrations exceed ERL values throughout the Bay system (Fig. 2e).

The results of the SEM/AVS study are shown in Figure 3. Acid volatile sulfide is generally abundant in Narragansett Bay sediments and tends to limit the bioavailability of trace metals even in areas with high trace metal concentrations. For this reason, trace metals are only likely to be bioavailable at a few stations scattered throughout the Narragansett Bay system.

2) <u>Sediment Cores</u>: Trace metal results from Apponaug Cove and the Seekonk River are similar to results previously obtained from these sites during the Narragansett Bay Project in 1988-89. Both sites show subsurface maxima and decreasing trends to the surface. The results from Quonset Point (Fig. 4) also show subsurface maxima and indicate a very rapid sedimentation rate. Estimates of the sedimentation rate at the Quonset Point site are 1-2 cm/year.

Comparison with Previous Data

A comparison was done between data obtained in 1988-89 during the Narragansett Bay Project and this project (1997-98) for twenty stations. The comparison for selected analyses is shown in Figure 5. Major decreases are observed for all analytes for stations with high trace metal concentrations in the Seekonk and Providence Rivers. On the other hand, stations in the mid-Bay either show little change, or slightly increased concentrations of some contaminants. The overall pattern of elevated metal concentrations in the upper reaches of the Narragansett Bay system and rapid decreases in metal concentrations in the mid- and lower-Bay is still observed, but the range of concentrations has decreased in the last decade.

Conclusions

1) Trace metal concentrations in surface sediments are elevated in the Seekonk, Providence, and Taunton Rivers. Some stations exceed ERM guidelines. Concentrations of trace metals decrease rapidly down bay.

2) The results of the SEM and AVS study indicate that trace metals are not generally bioavailable at stations with elevated trace metal concentrations because of the abundance of AVS. Metals tend to be sequestered in the form of insoluble sulfides when AVS is abundant. Metals are likely to be bioavailable at a variety of sites

scattered throughout the Bay system. The only common characteristics of these sites is that the sediments have higher sand contents and lower AVS contents than nearby stations.

3) Temporal trends derived from studies of sediment cores and comparisons of the NBP data from 1988-89 and the current study indicate that major decreases in trace metal contaminants have occurred in the upper reaches of Narragansett Bay. On the other hand, either little change, or slight increases in contaminant concentrations have been observed at some stations in the mid- and lower-Bay.

Student Involvement

1) Elizabeth Lacey: Beth received her PhD in May 1998 and received support from this project during her last year of graduate studies.

2) Shawn Doyle: Shawn received his BA in geology from URI in May 1998. He worked on this project during his senior year.

3) Patrick Dowling: Patrick received his BA in geology from URI in December 1997. He worked on this project during his last semester of undergraduate study and for three months after graduation as a technician.

Table 2:
1997-1998 NOAA Narragansett Bay Project
Inorganic Analyses

Trace Metals in Sediments: Total Digestion Method (μg/g)

- Aluminium
- Arsenic
- Cadmium
- Chromium
- Copper
- Iron
- Manganese
- Mercury
- Lead
- Nickel
- Silver
- Zinc

Trace Metals in Sediments: Partial Digestion Method (μg/g)

- Cadmium
- Chromium
- Copper
- Iron
- Manganese
- Lead
- Nickel
- Silver
- Zinc

Simultaneously Extracted Metals/Acid Volatile Sulfide (SEM/AVS)

- Simultaneously Extracted Metals: (μmole/gram)
    - Cadmium
    - Copper
    - Lead
    - Nickel
    - Zinc
- Acid Volatile Sulfide: Concentration of sulfide (μmole/gram)

Grain Size

- % Sand
- % Silt
- % Clay

Nutrients

- % Carbon
- % Nitrogen

Figure 1:
NOAA Narragansett Bay Project Station Locations

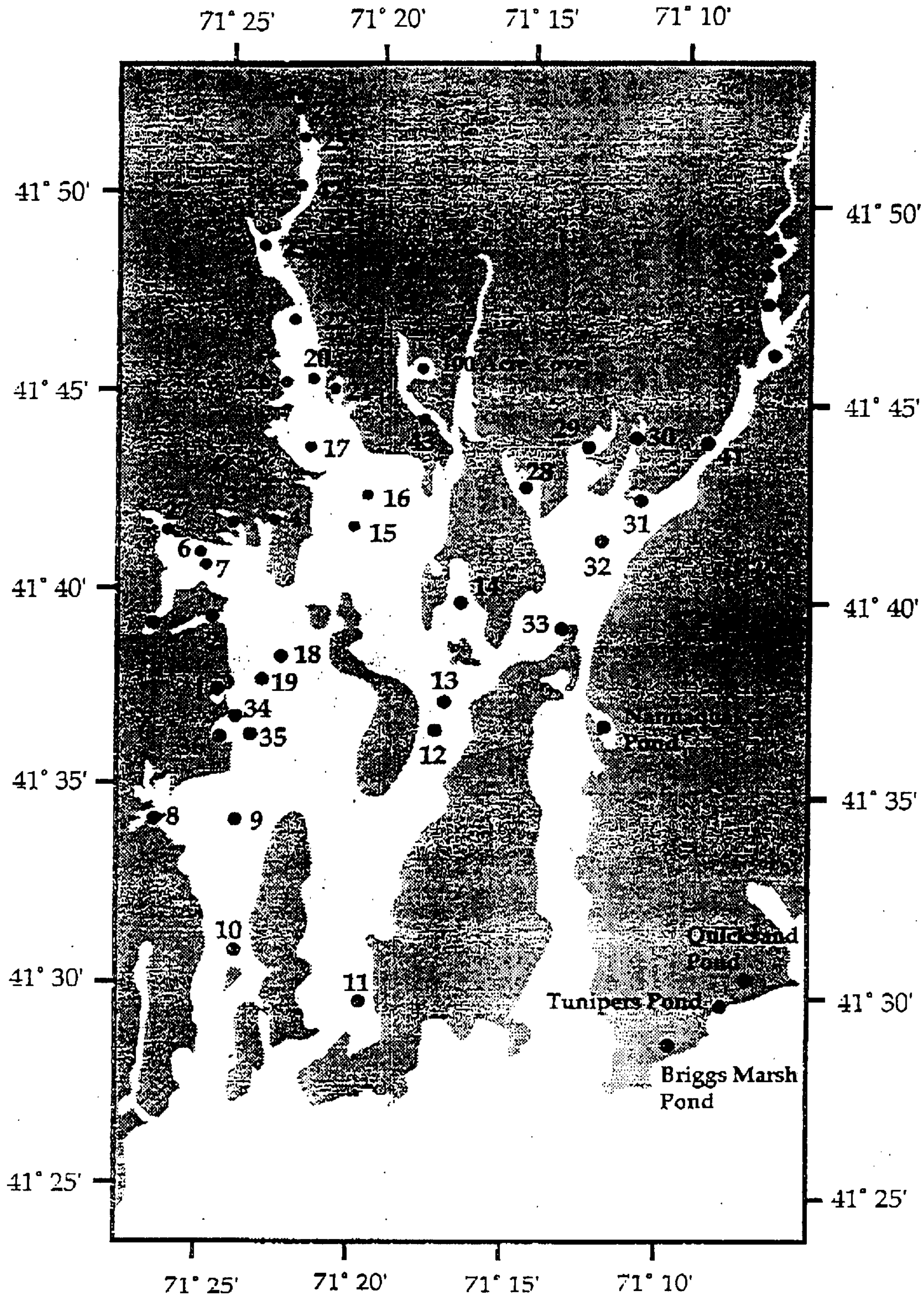


Figure 2e:
Arsenic (Total Digestions)

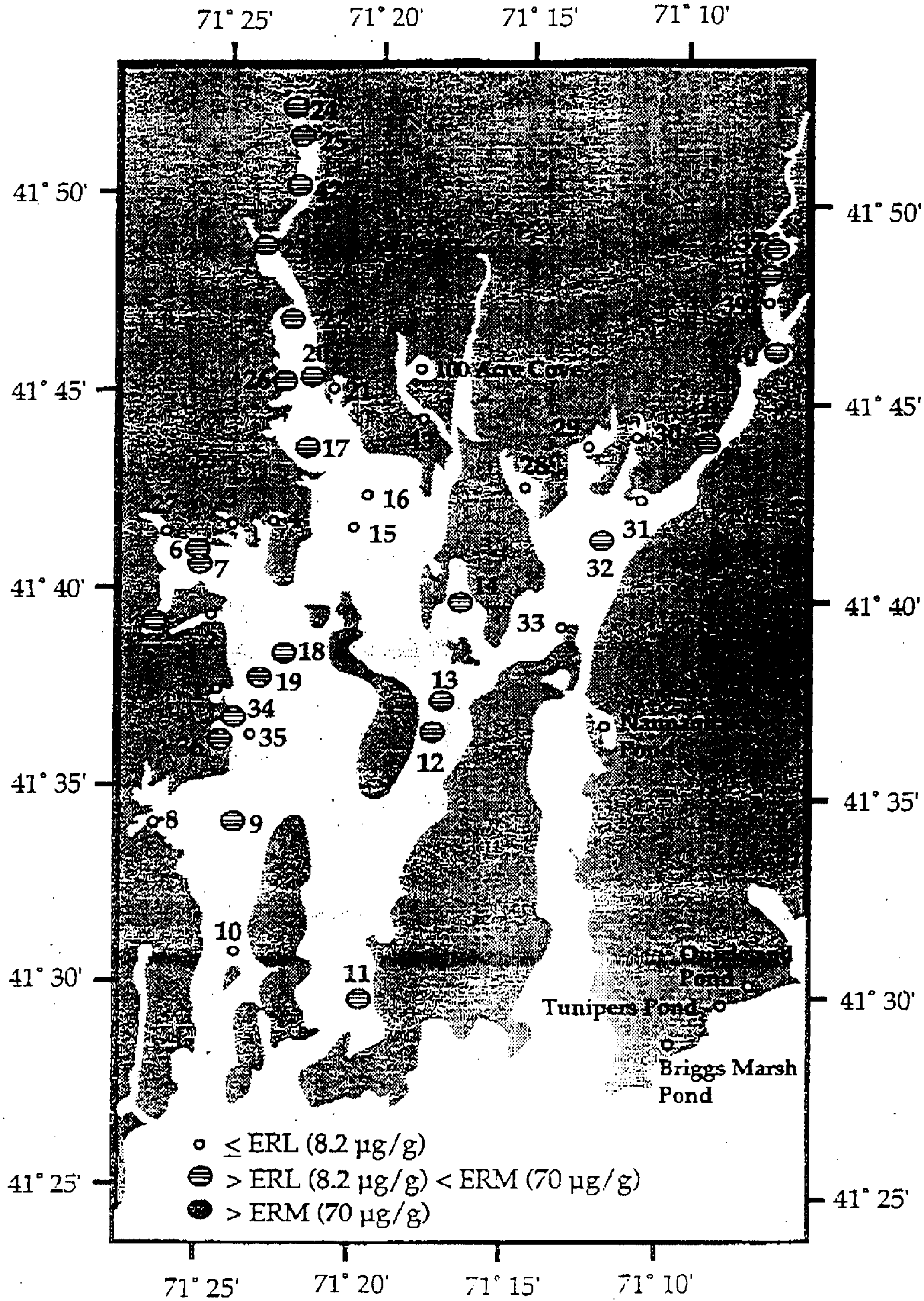


Figure 4:
NOAA Bay Project, Quonset Point Station (BP97-36)
Concentration of Trace Metals (µg/g) in Core Sediment

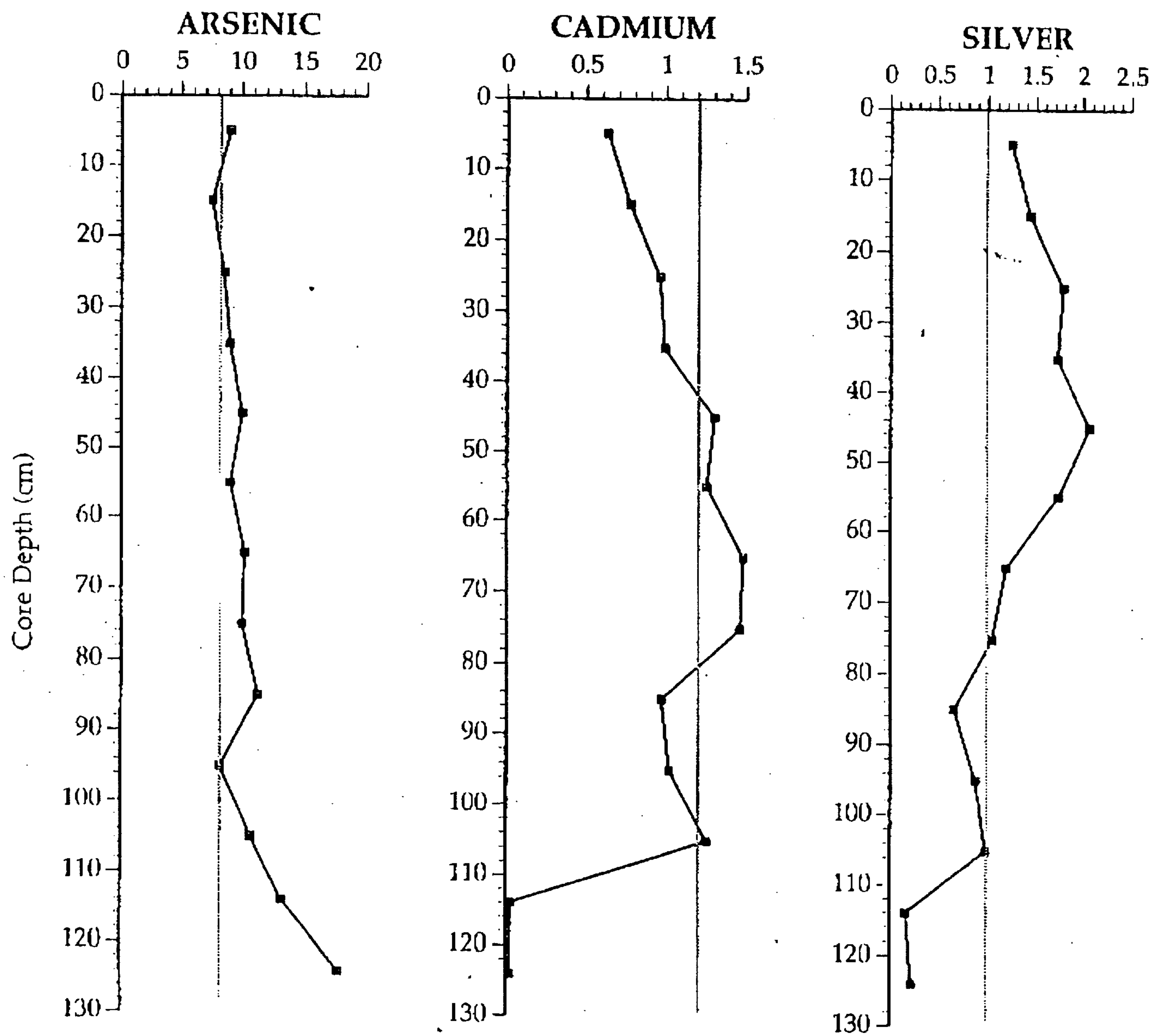
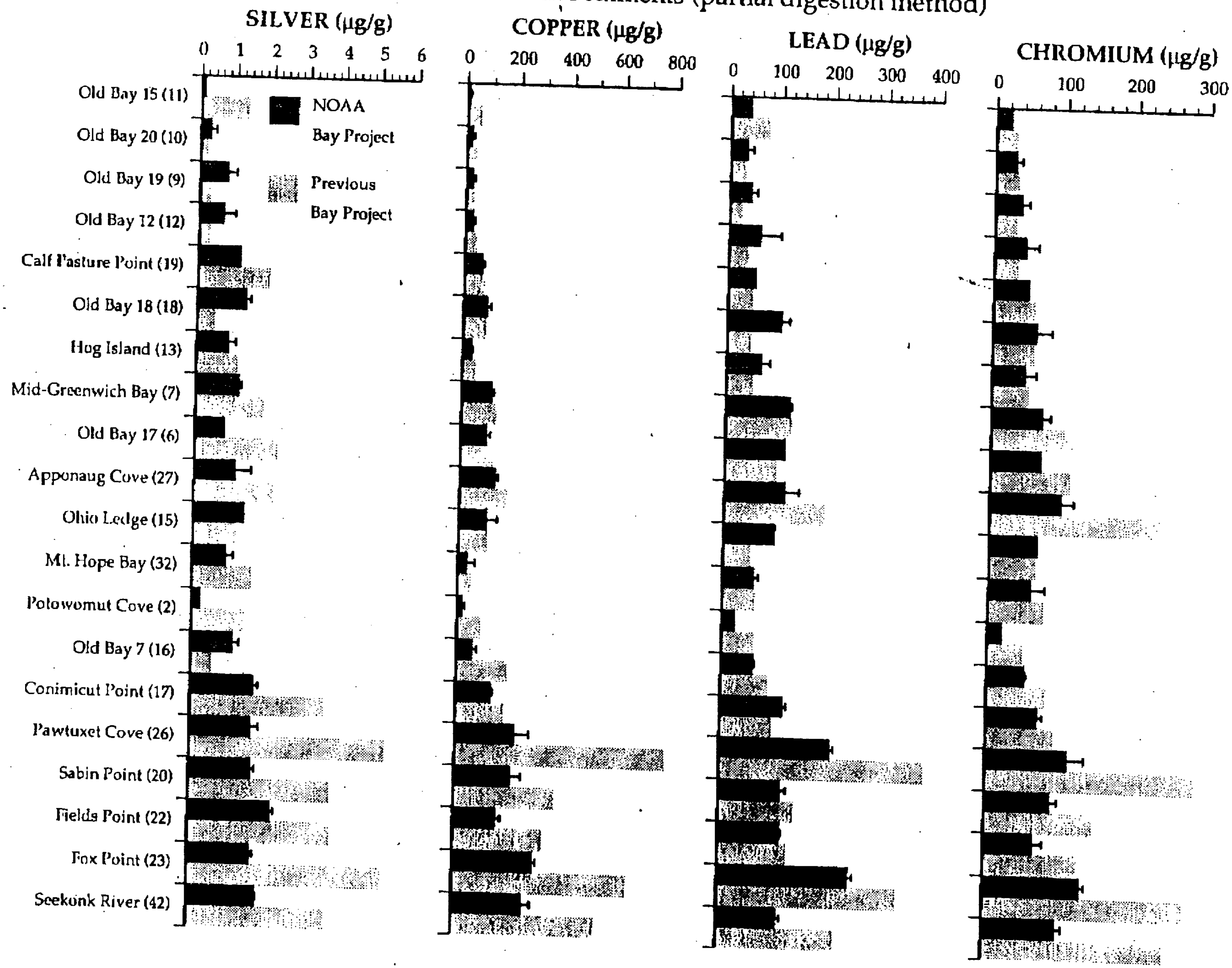


Figure 5:
Trace Metals in Sediments (partial digestion method)



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NBP-91-65 Mount Hope Bay "Briefing Paper" and Proceedings from Narragansett Bay Management Committee. 48 pp.

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NBP-92-93 The Land Management Project. The Land Management Project Completion Report. 71 pp.

NBP-92-94 The Land Management Project. The Land Management Project Publications Appendix.

NBP-92-101 The Land Management Project. Stormwater Basin Plants and Landscaping Guide: A Simple Guide for Designers and Communities.
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