Lavaca Bay Mercury Total Maximum Daily Load (TMDL) Study

Final Report

February 6, 2004

Submitted to:

Dr. Paul Montagna
University of Texas at Austin
Marine Science Institute
750 Channel View Drive
Port Aransas, Texas 78373, USA

Phone: 361-749-6779
Fax 361-749-6777
E-mail: paul@utmsi.utexas.edu

Principal Investigator:

Dr. Gary A. Gill
Laboratory for Oceanographic and Environmental Research
Texas A&M University at Galveston
5007 Avenue U
Galveston, TX 77551

gillg@tamug.tamu.edu (e-mail)
409-740-4710 (voice)

Umbrella Contract No. 582-1-30479 (UTMSI)
Subcontract No. UTA01-388 (TAMURF)
Total Maximum Daily Load Research Support
Work Order No. 582-1-30479-04

Table of Contents

List of Figures

List of Tables

Appendices

Executive Summary

TCEQ water quality segment 2453 (Lavaca Bay/Chocolate Bay) currently has an aquatic life closure for 2.5 square miles of the segment because of elevated mercury (Hg) levels in fin fish and crabs. In the Alcoa Ship Channel, the average mercury concentration in water exceeds the human health criterion for saltwater fish of 0.25 µg Hg/L of water (25 ng Hg/L). This closure has prompted the TCEQ to initiate a TMDL project for mercury (and oxygen, discussed separately) to address the concern.

In recent years, significant clean-up efforts have been initiated by the Aluminum Company of America (ALCOA) to reduce mercury contamination in water and sediments in the closed area as part of the Superfund process. Hence, TCEQ staff and the TMDL project scientists felt that it would be prudent to re-evaluate the water column concentrations of mercury to determine if mercury concentrations had fallen below the human health criterion.

A surface water sampling plan was developed to test this hypothesis. A series of 7 stations were identified for surface water sampling. Three were within the closed area and the others were placed around the site to represent "background" conditions. Sampling was conducted ten times at each station within a one year interval with a minimum of 30 days between sampling events. Samples were collected for the determination of total mercury (an unfiltered sample), filter-passing mercury, particulate mercury and several water chemistry parameters (suspended load, salinity, temperature, and dissolved oxygen).

Total Hg concentrations ranged between 2.03 and 25.2 ng/L and averaged 7.66 ± 5.39 ng/L for all 70 collections. Filter-passing Hg concentrations ranged between 0.44 and 4.19 ng/L and averaged 1.19 ± 0.77 ng/L for all 70 collections. Particulate Hg concentrations ranged between 0.014 and 1.41 ppm and averaged 0.27 ± 0.26 ppm for all 70 collections.

No samples within the closed area had a total mercury concentration that exceeded the human health criterion for saltwater fish of 0.25 µg Hg/L of water (25 ng Hg/L). One sample was collected that barely exceeded the limit (25.2 ng/L), but this sample was collected at the most southerly background site, not in the closed area.

Based on these results, it is recommended that segment 2453 be de-listed from the 303(d) list of impaired water bodies for elevated mercury concentration in water.

Introduction

This project provides technical support to the Texas Commission on Environmental Quality (TCEQ) for the development of total maximum daily loads (TMDL) for mercury and oxygen in Lavaca Bay and Chocolate Bay (segment 2453). The TCEQ will lead an effort to assess the causes and sources of the following water quality problems identified in the FY 2000 State of Texas Clean Water Act 303(d) list for Lavaca Bay/Chocolate Bay (Segment 2453). The TCEQ water quality segment 2453 (Lavaca Bay/Chocolate Bay) currently has aquatic life closure for 2.5 square miles of the segment because of elevated mercury (Hg) levels in fin fish and crabs. In the Alcoa Ship Channel, the average Hg concentration in water exceeds the human health criterion for saltwater fish. Low dissolved oxygen (DO) levels in the Red Bluff Channel contribute to partial support of the exceptional aquatic life use.

This report provides the results of the study for mercury only; the oxygen portion of the study is given in a separate report (Lavaca Bay TMDL Dissolved Oxygen Assessment Report).

Long Term Project Objectives

The long-term objectives of this TMDL project are to:

(1) Acquire data and information necessary to support modeling and assessment activities.

(2) Perform the modeling and assessment activities necessary to allocate the loadings of the constituents of concern.

(3) Assist the TCEQ if necessary in preparing an implementation plan specifying the actions necessary to achieve the recommended loading allocations. An intensive assessment of the water body is required to achieve these objectives.

Mercury Surface Water Sampling Plan

Significant clean-up efforts in Lavaca Bay have taken place in the last few years as part of the EPA Superfund process. This effort is believed to have eliminated on-going mercury sources. As such, these efforts may have already reduced the water column mercury levels sufficiently to allow a de-listing of water in Lavaca Bay from the 303(d) list of impaired water bodies. This sampling program was designed to test this hypothesis. The Goal of this project is to Determine if mercury levels in water in the closed area of Lavaca Bay have dropped below the human health criterion for saltwater fish (0.025 µg/L or 25 ng/L).

Historical Data Review

A historical review of mercury in water and finfish in Lavaca Bay was conducted as part of the Lavaca Bay mercury and dissolved oxygen Total Maximum Daily Load (TMDL) study project. This report was submitted to the TCEQ in January of 2003 and the full text is available as a separate document accompanying this report. Briefly, the major findings of this historical review for mercury are:

1. The historical database for aqueous mercury concentrations in water is sparse and some of the information is of dubious quality due to concerns about adequate sample collections methods for low level mercury measurements.

2. There is no recent (within the last 5 years) comprehensive information on mercury in water for Lavaca Bay.

3. The historical database for mercury in fish is much more abundant, both in time and geographic spread, providing much greater detail than the aqueous database.

4. The fish tissue database is very current; the most recent data are for Fall 2001.

Methods

Approach

A series of surface water sampling stations was occupied to monitor for total, filter-passing, and suspended particulate mercury content along with several ancillary water quality parameters. Sampling stations were spatially spread through out Lavaca Bay, focusing more intensely on the closed area, and in particular the ship channel leading to the Alcoa plant. Other stations were positioned to look for sources from the city of Port Lavaca and also from the Lavaca River. Background stations in the middle of the Bays are also included as these sites are considered to be removed from any local shoreline based point sources. These stations were chosen with a potential view toward the development of a TMDL for mercury in water, based on a "whole watershed" approach as well as a "point source" scenario should such efforts be necessary.

Sampling Schedule

A total of 10 sampling events were conducted beginning in August 2002 and concluding in August of 2003 (Table 1). Sampling was conducted at all seven sites with a minimum of 30 days between sampling events.

Table 1. Sample Collection Schedule

Sampling Event	Date
1	8/14/2002
2	9/21/2002
3	10/22/2002
4	12/5/2002
5	1/20/2003
6	2/21/2003
7	4/1/2003
8	5/21/2003
9	6/25/2003
10	8/5/2003

Lavaca Bay Water Sampling Stations

A total of 7 sites were chosen for surface water sampling. Figure 1 depicts the location of the sampling stations in Lavaca Bay. The station name and location are given in Table 2. Five of the 7 stations were chosen from existing TCEQ stations and two additional stations were added (new TCEQ stations 17857 and 17853) to obtain the desired spatial coverage.

Figure 1. Location of Sampling Stations

Table 2. Sampling Station Names, TCEQ Numbers and Locations for Surface Water Sampling Plan for Mercury

Station	TCEQ Short Description	Latitude	Longitude
13384	Lavaca Bay at 'Y' at CM 66	N28.59583	W96.56250
13385	Lavaca Bay at Alcoa Ship Dock	N28.64451	W96.56339
13563	Lavaca Bay at CM 22	N28.67972	W96.58222
14394	Lavaca Bay at W. Side of Alcoa	N28.65996	W96.56850
17558	Lavaca Bay at Pt Lavaca E SH36	N28.61314	W96.61378
17853	Lavaca Bay ENE of Port Lavaca	N28.62617	W96.58388
17857	Lavaca Bay Alcoa Ship Channel	N28.65080	W96.56460

Sampling and Analysis Procedures

Surface water sampling was conducted from a small boat using a peristaltic pump system equipped with Teflon inlet and outlet tubing (Flegal et al., 1991; Stordal et al., 1996; Wen et al., 1999). Samples were collected from depths between 20 and 50 cm. Unfiltered samples were directly collected into Teflon bottles using ultra-clean sample collection protocols as outlined in the QAPP (LOER SOP # 031). Filtered samples were directly collected into Teflon bottles by placing an in-line filtration cartridge on the outlet side of the tubing coming from peristaltic pump system. Sample analysis was conducted using procedures described in the QAPP (LOER SOP # 001). One randomly chosen site was sampled twice during each sampling period for quality assurance purposes.

Results

Summarized in the section below, are the results for total, filter-passing and particulate Hg along with selected water chemistry parameters at the seven stations in Lavaca Bay. Complete numerical results are given in the appendix. Summaries are provided in the tables and figures below.

Mercury Concentrations

A summary of the unfiltered, filter-passing and particulate mercury concentrations for each sampling station is given in Table 3. Total Hg concentrations ranged between 2.03 and 25.2 ng/L, filter-passing Hg concentrations ranged between 0.44 and 4.19 ng/L and particulate Hg concentrations ranged between 0.014 and 1.41 ppm for all 70 collections.

Table 3. Mean, Standard Deviation and Relative Standard Deviation for Total, Filter-Passing and Particulate Mercury at the Individual Stations in Lavaca Bay

	Unfiltered Hg (ng/L)			Filter-Passing Hg (ng/L)			Particulate Hg (ppm)		
Station	Mean	Std	RSD	Mean	Std	RSD	Mean	Std	RSD
14394	12.1	6.87	57%	1.48	0.44	30%	0.56	0.31	55%
17857	11.1	4.27	39%	1.64	1.07	65%	0.52	0.36	69%
13385	5.81	3.30	57%	1.10	0.39	36%	0.28	0.13	47%
17853	6.42	4.24	66%	1.11	0.85	77%	0.13	0.05	33%
17558	3.83	1.75	46%	0.81	0.57	71%	0.09	0.05	52%
13384	8.98	7.19	80%	1.18	1.08	92%	0.15	0.07	46%
13563	5.40	3.01	56%	0.98	0.49	50%	0.12	0.11	86%
All	7.66	5.39	70%	1.19	0.77	65%	0.27	0.26	98%

Particle-Water Partition Coefficient

Mercury is well known to be highly particle reactive. The interaction of mercury with suspended particulate matter can be characterized with a particle-water partition coefficient:

$$K_d\ (L/mg) = \frac{[Hg]_{particles}}{[Hg]_{water}}$$

Where $[Hg]_{particles}$ is the concentration of mercury on suspended particles in the water column in units of micrograms of Hg per gram of particles (µg/g); and

$[Hg]_{water}$ is the concentration of "dissolved" mercury in the water in units of nanograms of Hg per liter of water (ng/L). The mean particle water partition coefficient for mercury at all the stations in Lavaca Bay was log K_d = 5.25 ± 0.44 Individual averages for each station are summarized in Table 4. Sequential measurements of the particle-water partition coefficient for mercury for 10 sampling periods at each sampling site are shown in figure 8. Mean and standard deviation for 10 particle-water partition coefficient measurements of mercury at each sampling station are given in figure 9.

Table 4 Particle-Water Partition Coefficient for Mercury

Station	Particle-Water Partition Coefficient for Mercury (expressed as log K_d)		
	Mean	Std	RSD
14394	5.54	0.26	4.7%
17857	5.50	0.33	6.0%
13385	5.40	0.25	4.6%
17853	5.12	0.44	8.5%
17558	5.03	0.53	10.6%
13384	5.13	0.52	10.1%
13563	5.03	0.41	8.2%
All	5.25	0.44	8.0%

Water Chemistry Parameters

Several water chemistry parameters were obtained as part of the sample collection program including: suspended load, salinity, temperature, dissolved oxygen and pH. A summary of average suspended load and salinity values by station is given in Table 5. Complete results are given in the appendix.

Table 5. Mean, Standard Deviation and Relative Standard Deviation for Suspended Load and Salinity at the Individual Stations in Lavaca Bay.

Station	Suspended Load (mg/L)			Salinity (ppt)		
	Mean	Std	RSD	Mean	Std	RSD
14394	23.1	11.7	50%	19.6	4.9	25%
17857	19.4	7.3	38%	19.0	4.1	21%
13385	18.9	6.80	36%	20.7	3.0	14%
17853	66.3	97.6	147%	16.2	5.2	32%
17558	64.5	61.6	96%	17.5	3.7	21%
13384	70.4	66.5	94%	18.4	4.4	24%
13563	88.6	132	149%	12.4	4.4	36%

Figure 2. Sequential Measurements of Total Mercury Concentration for 10 sampling periods at each Sampling Site

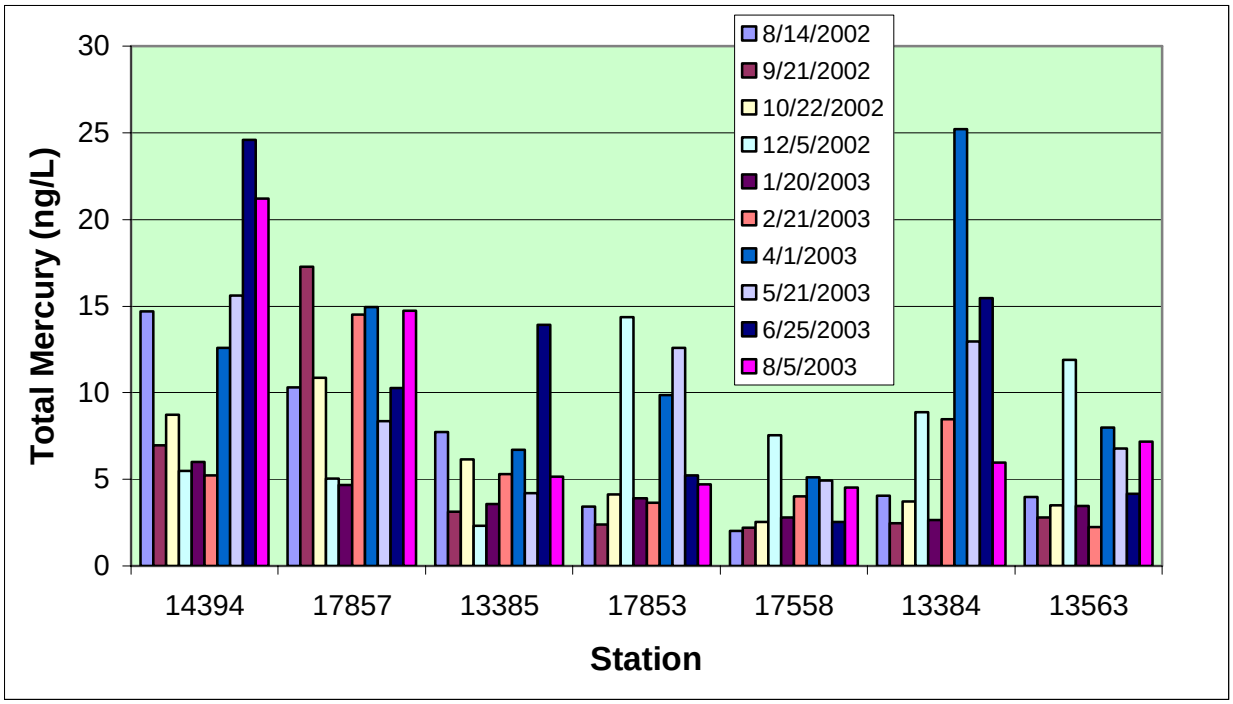


Figure 3. Mean and Standard Deviation for 10 Total Mercury Measurements at Each Sampling Station

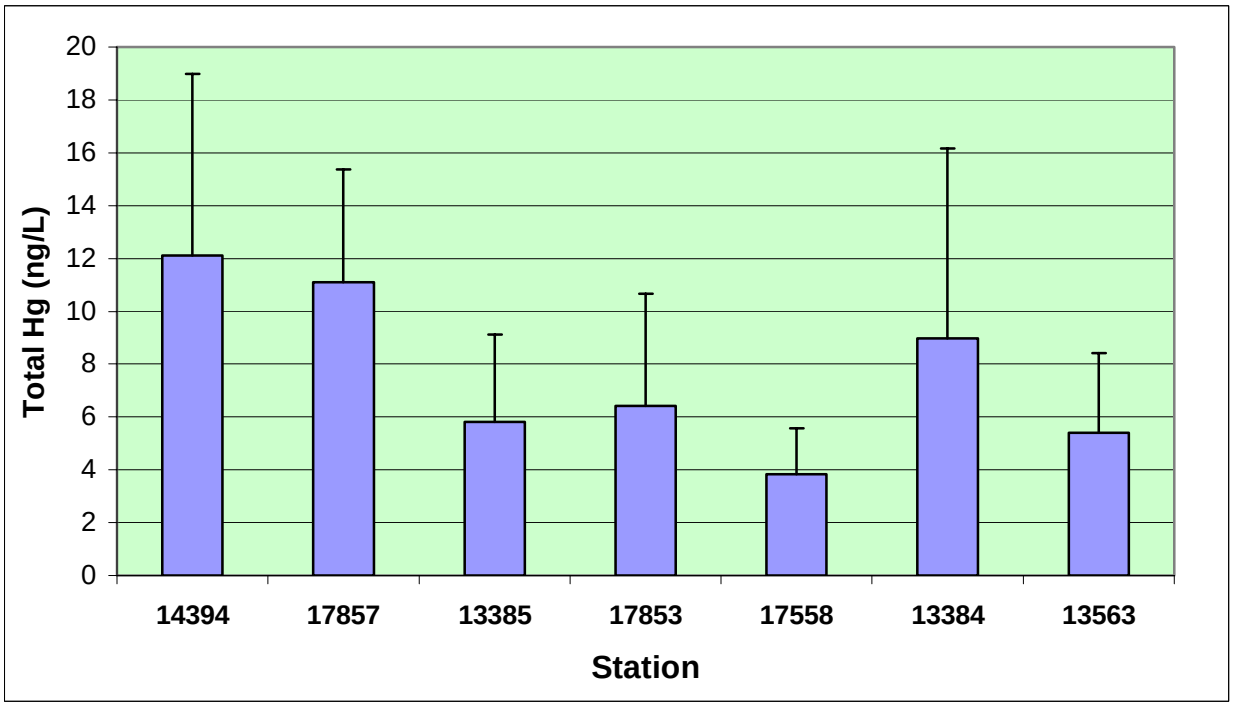


Figure 4. Sequential Measurements of Filter-Passing Concentration for 10 sampling periods at each Sampling Site

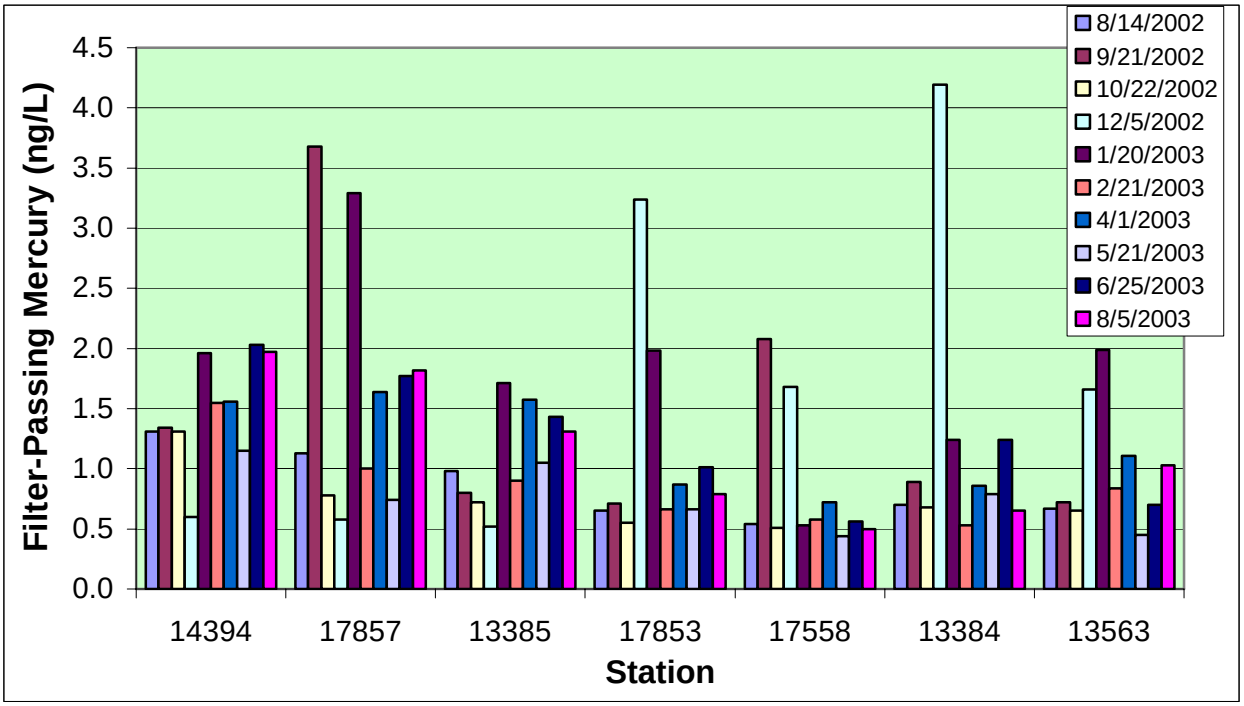


Figure 5. Mean and Standard Deviation for 10 Filter-Passing Mercury Measurements at Each Sampling Station

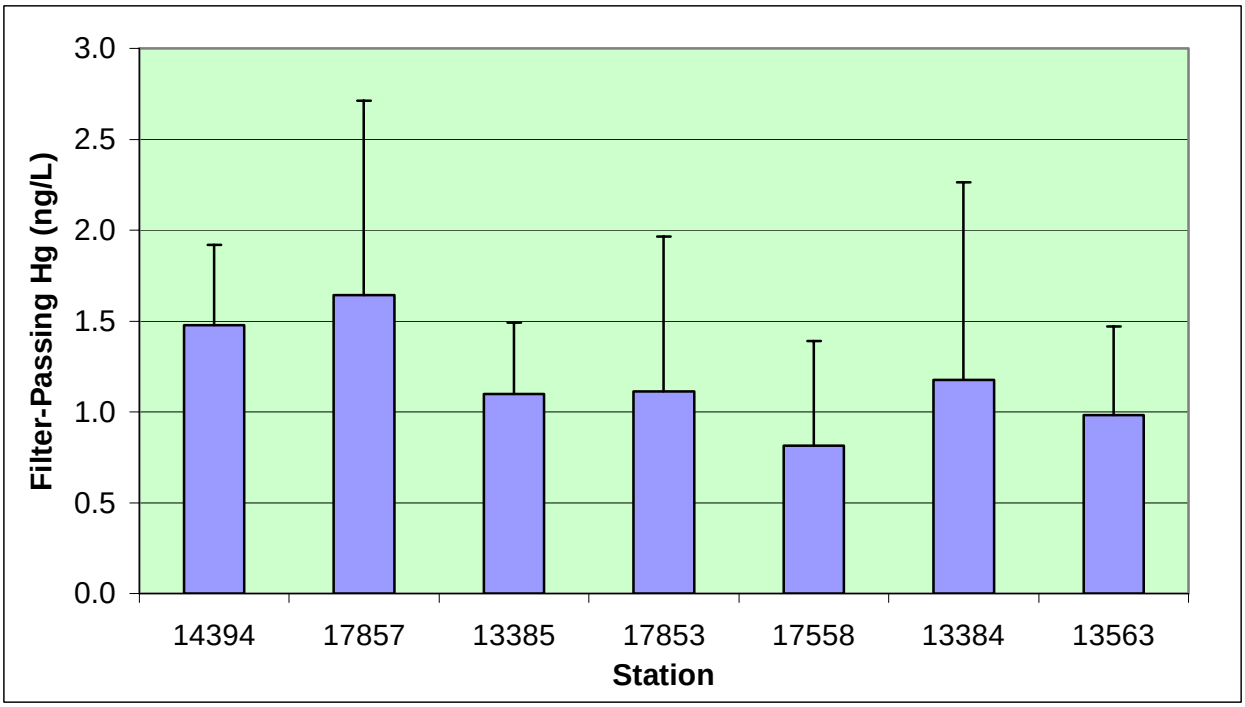


Figure 6. Sequential Measurements of Particulate Mercury Concentration for 10 Sampling Periods at Each Sampling Site

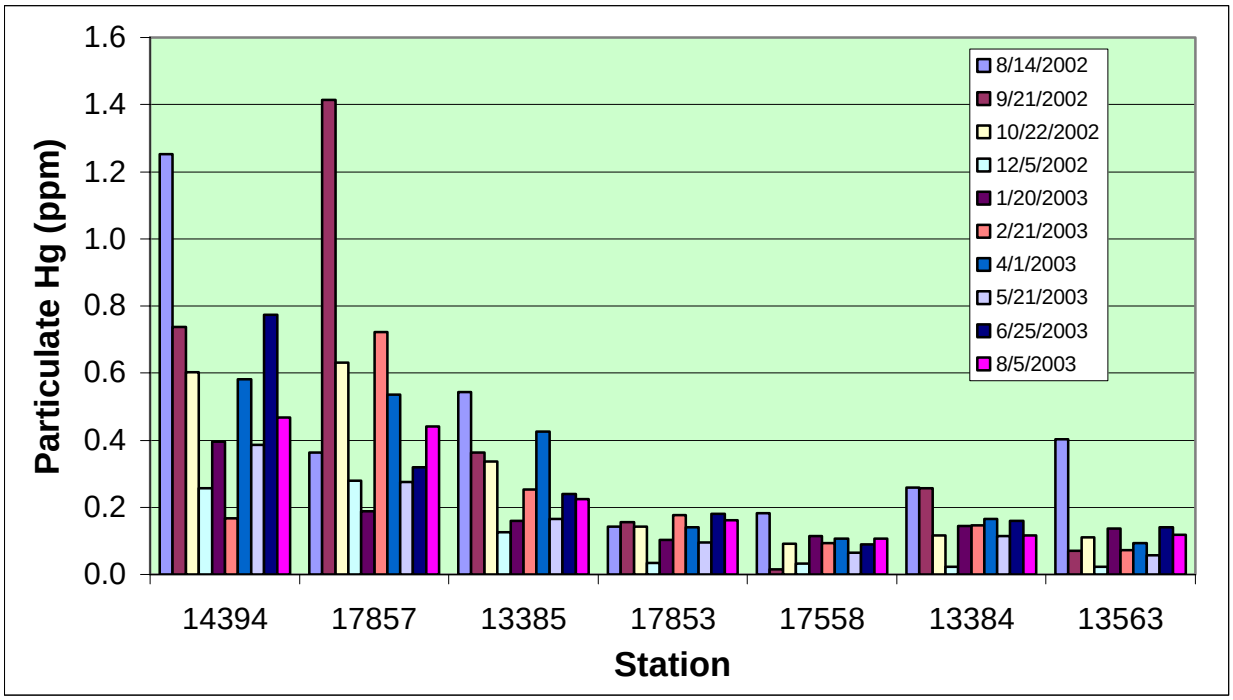


Figure 7. Mean and Standard Deviation for 10 Particulate Mercury Measurements at Each Sampling Station

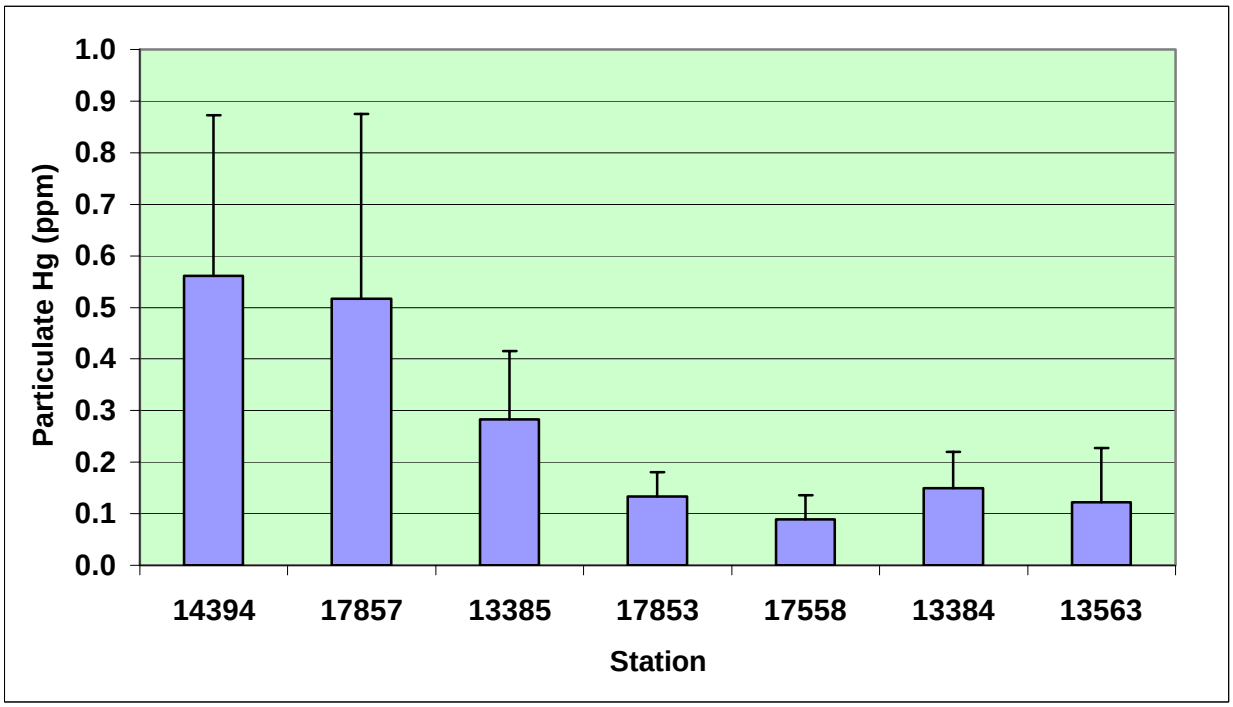


Figure 8. Sequential Measurements of the Particle-Water Partition Coefficient for Mercury for 10 Sampling Periods at Each Sampling Site

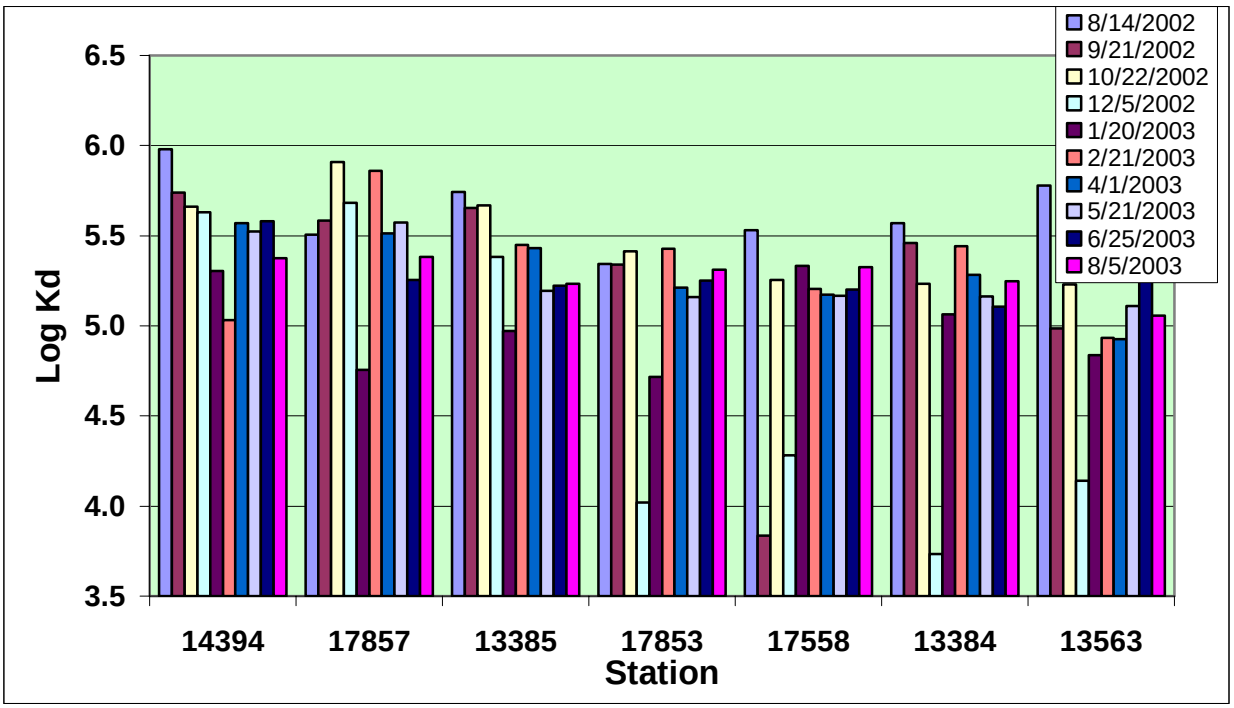


Figure 9. Mean and Standard Deviation for 10 Particle-Water Partition Coefficient Measurements of Mercury at Each Sampling Station

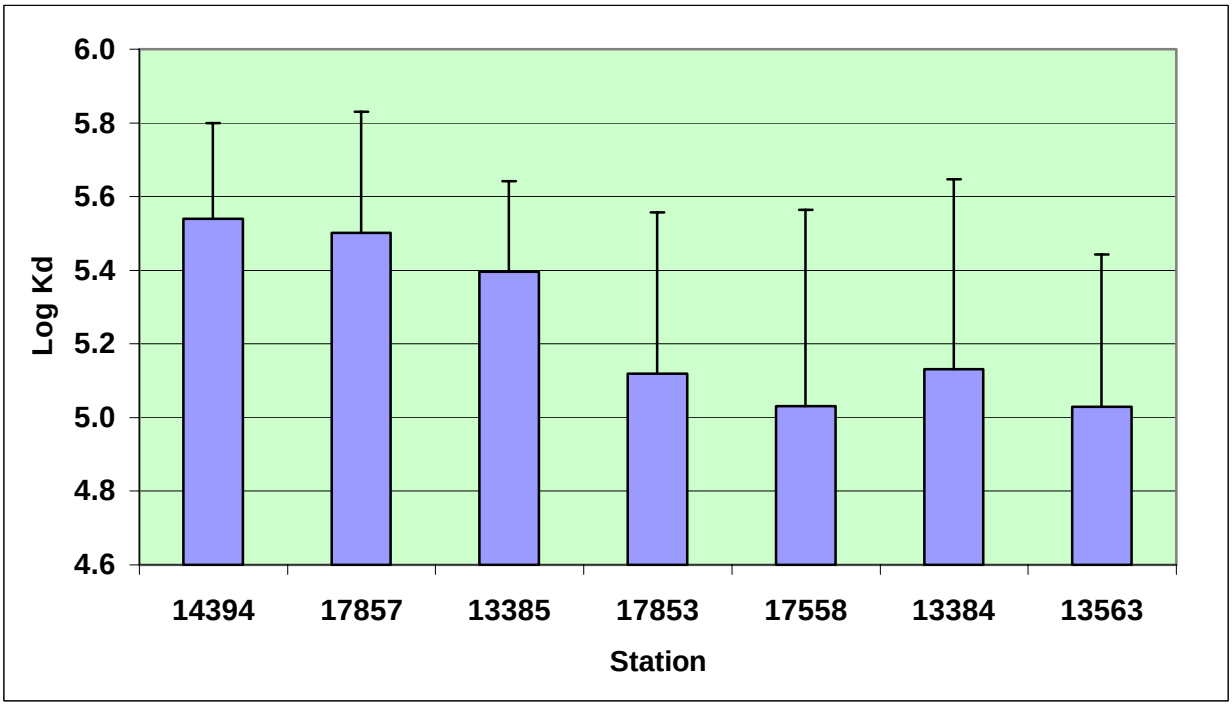


Figure 10. Sequential Measurements of Suspended Particulate Material for 10 Sampling Periods at Each Sampling Site

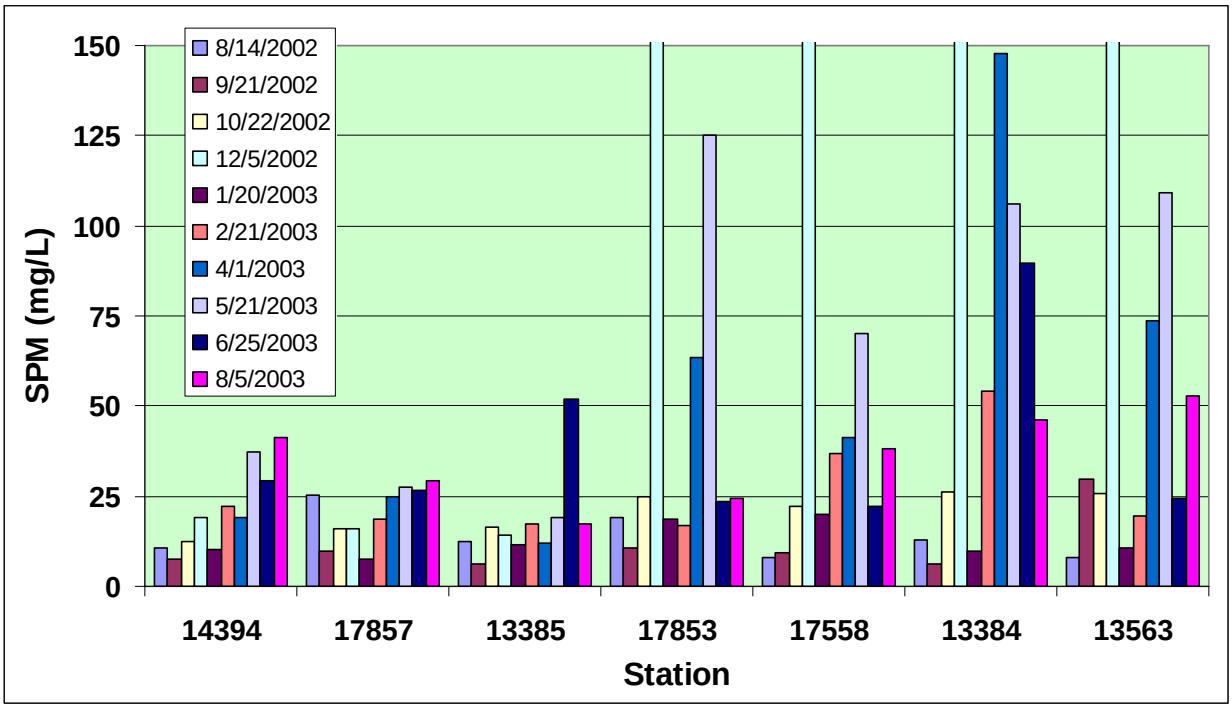
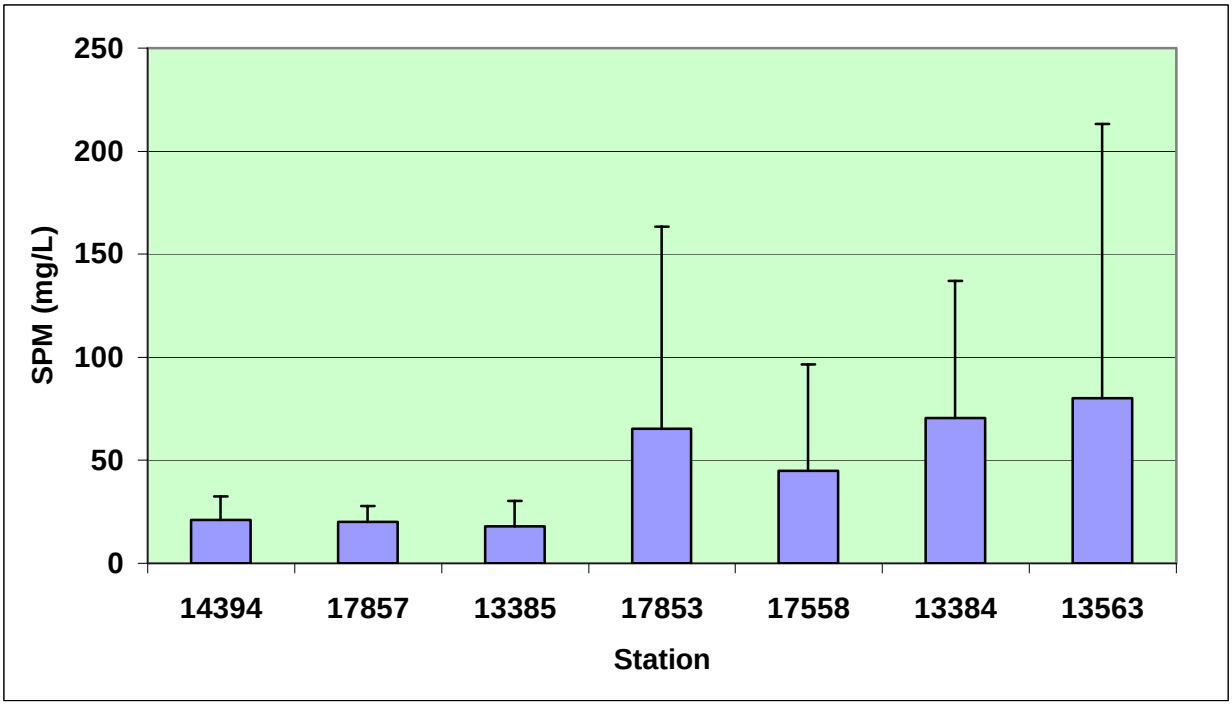


Figure 11. Mean and Standard Deviation for 10 Suspended Load Measurements at Each Sampling Station



Discussion

Comparison of Mercury Concentrations Between the Closed and Open Areas of Lavaca Bay

Three of the TCEQ stations (14394, 17857 and 13385) represent waters within the closed area of Lavaca Bay. A comparison of mercury concentrations observed between these closed are stations and sites in the open areas (stations 13563, 17853, 17558 and 13384) is given in Table 6. Mercury concentrations for all three phases (unfiltered, filter-passing and particulate) had higher average concentrations within the closed area compared to collections obtained from outside the closed area. While it is clear that there still exists an elevation of mercury levels within the closed area, none of the samples collected within the closed area exceeded the human health criterion for saltwater fish of 0.25 µg Hg/L of water (25 ng Hg/L).

Table 6. A Comparison of Mercury Concentrations Between the Open and Closed Areas of Lavaca Bay

Sample Type	Closed Area Mean (ng/L)	Closed Area Std (ng/L)	Closed Area RSD (%)	Open Area Mean (ng/L)	Open Area Std (ng/L)	Open Area RSD (%)
Unfiltered	9.67	5.6	58	6.16	4.74	77
Filtered	1.41	0.72	51	1.02	0.77	75
Particulate	0.45	0.30	66	0.12	0.07	58

Estuarine Mercury Concentrations Along the Texas Gulf Coast

There are very few measurements available with which to compare the results obtained in this report from Lavaca Bay with data collected from other estuaries along the Texas coast (Table 7). Based on this very limited comparison, it appears that mercury levels in Lavaca Bay are elevated two to three-fold over levels observed in other Texas estuaries.

For more information on Lavaca Bay see the historical review of mercury concentrations in water and fish in Lavaca Bay that were presented and discussed in a previous report as part of this TMDL project (Gill, 2003).

Table 7. Estuarine Mercury Concentrations Along the Texas Gulf Coast

Region	Mercury Concentration (ng/L) Total	Filter-Passing	Particulate	Reference
Galveston Bay		0.06 – 1.36[a]	0.64 - 24[a]	Stordal et al. (1996)
Galveston Bay	2.0 ± 3.9[b]	0.39 ± 0.24[b]	1.6 ± 3.8[b]	Lehman and Gill (2002)
Galveston Bay	4.42	1.05	3.37	Choe et al. (2001)
Corpus Christi Bay		0.24 – 1.64[a]		Stordal et al. (1996)
Sabine Lake		0.48 – 0.86[a]		Stordal et al. (1996)
Lavaca Bay	7.66 ± 5.39	1.19 ± 0.77		This Report

[a] range of values
[b] mean ± std. dev.

Importance of the Particulate Mercury Phase

As noted previously, mercury is well known to be highly particle reactive, readily attaching to surface adsorption sites on particles. The difference between unfiltered and filtered collections and the particle-water partition values observed in this study bear evidence of this environmental chemistry feature of mercury. To illustrate, the mean unfiltered mercury concentration for all collections was 7.66 ± 5.39 ng/L while the filter-passing mercury concentration was 1.19 ± 0.77 ng/L. Clearly, a majority of the mercury in the water column is associated with suspended particles. This feature is also borne out with the particle-water partition coefficient for mercury; the average log K_d for mercury in Lavaca Bay was 5.25 ± 0.44.

This strong interaction of mercury to attach to particulate phases combined with the particulate mercury concentration difference and the suspended particle concentration difference between open and closed areas collective have a dominant influence on the distribution patterns observed for mercury in this study. Note that average particulate mercury concentrations at stations in the closed area are elevated more than 2 to 4-fold over particulate mercury levels at stations outside the closed area (see Table 6 and Figure 7). At the same time, average suspended particulate matter levels in the closed area (20 ± 11 mg/L) are about one-third that of stations in the open areas (65 ± 90 mg/L) (see figure 11). The lower SPM levels in the closed area are probably a result of “sheltering” of the water body by Dredge Island to mixing from surface winds. This sheltering effectively diminishes the resuspension of bottom sediments into the water column. If this sheltering phenomenon did not take place, it is likely that the closed area unfiltered mercury concentrations would be 2-3 times higher than observed, which would likely elevate mercury levels above criteria limits. In addition, there may be times when favorable wind regimes act to increase SPM levels above the conditions observed in this study. During such times, it is possible that SPM levels will rise accordingly and mercury levels might exceed criteria levels.

Recommendations

No samples within the closed area had a total mercury concentration that exceeded the human health criterion for saltwater fish of 0.25 µg Hg/L of water (25 ng Hg/L). Only one sample was collected that (barely) exceeded the limit (25.2 ng/L), but this sample was collected at the most southerly background site, not in the closed area.

Based on these results, it is recommended that segment 2453 be de-listed from the 303(d) list of impaired water bodies for elevated mercury concentration in water.

Literature Cited

Choe, K.-Y., and G. A. Gill (2001). Isolation of colloidal monomethylmercury in natural waters using cross-flow ultrafiltration techniques. *Marine Chemistry*, **76**: 305-318.

Flegal, A.R., G.A. Gill, S. Sañudo, G. Smith, and L.C.D. Anderson (1991). Dissolved trace element cycling in San Francisco Bay estuary. *Marine Chemistry,* **36**:329-363.

Gill, G. A. (2003). Historical Data Review of Mercury in Water and Finfish for the Lavaca Bay Mercury and Dissolved Oxygen Total Maximum Daily Load (TMDL) Study. TCEQ Project 582-1-30479-01.

Lehman, R. and G. A. Gill (2002). Trace Metal Assessment of Selected Southeast Texas Bays and Bayous. TNRCC Project.

Stordal, M. C., G. A. Gill, L. S. Wen, and P. H. Santschi (1996). Mercury phase speciation in surface waters of three Texas estuaries: the importance of colloidal forms. *Limnology and Oceanography*, **41**:52-61.

Wen, L.-S., P. H. Santschi, G. A. Gill, and C. Paternostro (1999). Estuarine Trace Metal Distributions in Galveston Bay: Importance of Colloidal Forms in the Speciation of the Dissolved Phase. *Marine Chemistry*, **63**: 185-212.

Appendices

Appendix 1. Mercury Data Sorted by Sampling Station

Sampling Date	Mercury Unfiltered ng/L	Mercury Filtered ng/L	Mercury Particulate ppm	SPM mg/L	Partition Coefficient K_d mg/L	Partition Coefficient log K_d mg/L
Station 13384						
8/14/2002	4.04	0.70	0.26	12.9	3.70E+05	5.57
9/21/2002	2.46	0.89	0.26	6.10	2.89E+05	5.46
10/22/2002	3.71	0.68	0.12	26.0	1.71E+05	5.23
12/5/2002	8.86	4.19	0.02	205	5.43E+03	3.73
1/20/2003	2.65	1.24	0.14	9.80	1.16E+05	5.06
2/21/2003	8.48	0.53	0.15	54.2	2.77E+05	5.44
4/1/2003	25.2	0.86	0.16	148	1.91E+05	5.28
5/21/2003	13.0	0.79	0.11	106	1.45E+05	5.16
6/25/2003	15.5	1.24	0.16	89.6	1.28E+05	5.11
8/5/2003	5.95	0.65	0.12	46.0	1.77E+05	5.25
Mean	**8.98**	**1.18**	**0.15**	**70.4**	**1.87E+05**	**5.13**
Std	**7.19**	**1.08**	**0.07**	**66.5**	**1.03E+05**	**0.52**
RSD	**80.1%**	**92.2%**	**46.4%**	**94.5%**	**55.1%**	**10.1%**
Station 13385						
8/14/2002	7.72	0.98	0.54	12.4	5.55E+05	5.74
9/21/2002	3.12	0.80	0.36	6.4	4.53E+05	5.66
10/22/2002	6.16	0.72	0.34	16.2	4.66E+05	5.67
12/5/2002	2.31	0.52	0.13	14.3	2.41E+05	5.38
1/20/2003	3.57	1.71	0.16	11.6	9.38E+04	4.97
2/21/2003	5.29	0.90	0.25	17.4	2.80E+05	5.45
4/1/2003	6.70	1.58	0.42	12.1	2.70E+05	5.43
5/21/2003	4.20	1.05	0.16	19.1	1.57E+05	5.20
6/25/2003	13.9	1.43	0.24	52.1	1.67E+05	5.22
8/5/2003	5.16	1.31	0.22	17.2	1.71E+05	5.23
Mean	**5.81**	**1.10**	**0.28**	**17.9**	**2.85E+05**	**5.40**
Std	**3.30**	**0.39**	**0.13**	**12.6**	**1.55E+05**	**0.25**
RSD	**56.7%**	**35.6%**	**46.7%**	**70.4%**	**54.3%**	**4.6%**
Station 13563						
8/14/2002	3.98	0.67	0.40	8.20	6.02E+05	5.78
9/21/2002	2.80	0.72	0.07	29.9	9.66E+04	4.99
10/22/2002	3.49	0.65	0.11	25.8	1.69E+05	5.23
12/5/2002	11.9	1.66	0.02	448	1.38E+04	4.14
1/20/2003	3.45	1.99	0.14	10.7	6.86E+04	4.84
2/21/2003	2.26	0.84	0.07	19.7	8.58E+04	4.93
4/1/2003	8.00	1.11	0.09	73.7	8.42E+04	4.93

Sampling Date	Mercury Unfiltered ng/L	Mercury Filtered ng/L	Mercury Particulate ppm	SPM mg/L	Partition Coefficient K_d mg/L	Partition Coefficient log K_d mg/L
5/21/2003	6.76	0.45	0.06	109	1.29E+05	5.11
6/25/2003	4.15	0.70	0.14	24.5	2.01E+05	5.30
8/5/2003	7.19	1.03	0.12	52.7	1.13E+05	5.05
Mean	**5.40**	**0.98**	**0.12**	**80.2**	**1.56E+05**	**5.03**
Std	**3.01**	**0.49**	**0.11**	**133**	**1.65E+05**	**0.41**
RSD	**55.8%**	**49.8%**	**86.2%**	**165.8%**	**105.6%**	**8.2%**
Station 14394						
8/14/2002	14.7	1.31	1.25	10.7	9.55E+05	5.98
9/21/2002	6.95	1.34	0.74	7.60	5.51E+05	5.74
10/22/2002	8.73	1.31	0.60	12.3	4.60E+05	5.66
12/5/2002	5.49	0.6	0.26	19.1	4.27E+05	5.63
1/20/2003	5.99	1.96	0.40	10.2	2.02E+05	5.30
2/21/2003	5.24	1.55	0.17	22.1	1.08E+05	5.03
4/1/2003	12.6	1.56	0.58	19.0	3.72E+05	5.57
5/21/2003	15.6	1.15	0.39	37.5	3.35E+05	5.53
6/25/2003	24.6	2.03	0.77	29.2	3.81E+05	5.58
8/5/2003	21.2	1.97	0.47	41.2	2.37E+05	5.37
Mean	**12.1**	**1.48**	**0.56**	**20.9**	**4.03E+05**	**5.54**
Std	**6.87**	**0.44**	**0.31**	**11.7**	**2.34E+05**	**0.26**
RSD	**56.7%**	**29.8%**	**55.4%**	**56.1%**	**58.1%**	**4.7%**
Station 17558						
8/14/2002	2.03	0.54	0.18	8.16	3.38E+05	5.53
9/21/2002	2.21	2.08	0.01	9.10	6.87E+03	3.84
10/22/2002	2.53	0.51	0.09	22.1	1.79E+05	5.25
12/5/2002	7.54	1.68	0.03	182	1.91E+04	4.28
1/20/2003	2.79	0.53	0.11	19.9	2.14E+05	5.33
2/21/2003	4.02	0.58	0.09	36.9	1.61E+05	5.21
4/1/2003	5.13	0.72	0.11	41.2	1.49E+05	5.17
5/21/2003	4.95	0.44	0.06	69.9	1.47E+05	5.17
6/25/2003	2.53	0.56	0.09	22.2	1.58E+05	5.20
8/5/2003	4.53	0.5	0.11	38.1	2.12E+05	5.33
Mean	**3.83**	**0.81**	**0.09**	**45.0**	**1.58E+05**	**5.03**
Std	**1.75**	**0.57**	**0.05**	**51.6**	**9.50E+04**	**0.53**
RSD	**45.7%**	**70.5%**	**52.0%**	**114.6%**	**60.0%**	**10.6%**
Station 17853						
8/14/2002	3.41	0.65	0.14	19.3	2.20E+05	5.34
9/21/2002	2.39	0.71	0.16	10.8	2.19E+05	5.34
10/22/2002	4.13	0.55	0.14	25.0	2.60E+05	5.42
12/5/2002	14.3	3.24	0.03	327	1.05E+04	4.02
1/20/2003	3.91	1.98	0.10	18.7	5.21E+04	4.72
2/21/2003	3.66	0.66	0.18	16.9	2.69E+05	5.43
4/1/2003	9.87	0.87	0.14	63.6	1.63E+05	5.21
5/21/2003	12.6	0.66	0.10	125	1.44E+05	5.16

Sampling Date	Mercury Unfiltered ng/L	Mercury Filtered ng/L	Mercury Particulate ppm	SPM mg/L	Partition Coefficient K_d mg/L	Partition Coefficient log K_d mg/L
6/25/2003	5.24	1.01	0.18	23.5	1.78E+05	5.25
8/5/2003	4.70	0.79	0.16	24.2	2.05E+05	5.31
Mean	**6.42**	**1.11**	**0.13**	**65.4**	**1.72E+05**	**5.12**
Std	**4.24**	**0.85**	**0.04**	**98.1**	**8.44E+04**	**0.44**
RSD	**66.0%**	**76.7%**	**33.4%**	**150.0%**	**49.0%**	**8.5%**
Station 17857						
8/14/2002	10.3	1.13	0.36	25.3	3.21E+05	5.51
9/21/2002	17.3	3.68	1.41	9.6	3.84E+05	5.58
10/22/2002	10.9	0.78	0.63	16.0	8.08E+05	5.91
12/5/2002	5.04	0.58	0.28	16.0	4.81E+05	5.68
1/20/2003	4.68	3.29	0.19	7.40	5.71E+04	4.76
2/21/2003	14.5	1.00	0.72	18.7	7.22E+05	5.86
4/1/2003	14.9	1.64	0.54	24.8	3.27E+05	5.51
5/21/2003	8.34	0.74	0.28	27.5	3.73E+05	5.57
6/25/2003	10.3	1.77	0.32	26.7	1.80E+05	5.26
8/5/2003	14.7	1.82	0.44	29.3	2.42E+05	5.38
Mean	**11.1**	**1.64**	**0.52**	**20.1**	**3.90E+05**	**5.50**
Std	**4.27**	**1.07**	**0.36**	**7.7**	**2.31E+05**	**0.33**
RSD	**38.5%**	**65.0%**	**69.3%**	**38.5%**	**59.2%**	**6.0%**

Appendix 2. Mercury Data Sorted By Sampling Date

Sampling Date	Sampling Station	Mercury Unfiltered ng/L	Mercury Filtered ng/L	Particulate ppm	SPM mg/L	Kd mg/L	log Kd mg/L
8/14/2002	14394	14.7	1.31	1.25	10.7	9.55E+05	5.98
	17857	10.3	1.13	0.36	25.3	3.21E+05	5.51
	13385	7.72	0.98	0.54	12.4	5.55E+05	5.74
	17853	3.41	0.65	0.14	19.3	2.20E+05	5.34
	17558	2.03	0.54	0.18	8.16	3.38E+05	5.53
	13384	4.04	0.70	0.26	12.9	3.70E+05	5.57
	13563	3.98	0.67	0.40	8.2	6.02E+05	5.78
9/21/2002	14394	6.95	1.34	0.74	7.6	5.51E+05	5.74
	17857	17.3	3.68	1.41	9.6	3.84E+05	5.58
	13385	3.12	0.8	0.36	6.4	4.53E+05	5.66
	17853	2.39	0.71	0.16	10.8	2.19E+05	5.34
	17558	2.21	2.08	0.014	9.1	6.87E+03	3.84
	13384	2.46	0.89	0.26	6.1	2.89E+05	5.46
	13563	2.80	0.72	0.07	29.9	9.66E+04	4.99
10/22/2002	14394	8.73	1.31	0.60	12.3	4.60E+05	5.66
	17857	10.9	0.78	0.63	16.0	8.08E+05	5.91
	13385	6.16	0.72	0.34	16.2	4.66E+05	5.67
	17853	4.13	0.55	0.14	25.0	2.60E+05	5.42
	17558	2.53	0.51	0.09	22.1	1.79E+05	5.25
	13384	3.71	0.68	0.12	26.0	1.71E+05	5.23
	13563	3.49	0.65	0.11	25.8	1.69E+05	5.23
12/5/2002	14394	5.49	0.60	0.26	19.1	4.27E+05	5.63
	17857	5.04	0.58	0.28	16.0	4.81E+05	5.68
	13385	2.31	0.52	0.13	14.3	2.41E+05	5.38
	17853	14.4	3.24	0.034	327	1.05E+04	4.02
	17558	7.54	1.68	0.032	182	1.91E+04	4.28
	13384	8.86	4.19	0.023	205	5.43E+03	3.73
	13563	11.9	1.66	0.023	448	1.38E+04	4.14
1/20/2003	14394	5.99	1.96	0.40	10.2	2.02E+05	5.30
	17857	4.68	3.29	0.19	7.4	5.71E+04	4.76
	13385	3.57	1.71	0.16	11.6	9.38E+04	4.97
	17853	3.91	1.98	0.10	18.7	5.21E+04	4.72
	17558	2.79	0.53	0.11	19.9	2.14E+05	5.33
	13384	2.65	1.24	0.14	9.8	1.16E+05	5.06
	13563	3.45	1.99	0.14	10.7	6.86E+04	4.84

Sampling Date	Sampling Station	Mercury Unfiltered ng/L	Mercury Filtered ng/L	Particulate ppm	SPM mg/L	Kd mg/L	log Kd mg/L
2/21/2003	14394	5.24	1.55	0.17	22.1	1.08E+05	5.03
	17857	14.5	1.00	0.72	18.7	7.22E+05	5.86
	13385	5.29	0.90	0.25	17.4	2.80E+05	5.45
	17853	3.66	0.66	0.18	16.9	2.69E+05	5.43
	17558	4.02	0.58	0.093	36.9	1.61E+05	5.21
	13384	8.48	0.53	0.15	54.2	2.77E+05	5.44
	13563	2.26	0.84	0.07	19.7	8.58E+04	4.93
4/1/2003	14394	12.6	1.56	0.58	19.0	3.72E+05	5.57
	17857	14.9	1.64	0.54	24.8	3.27E+05	5.51
	13385	6.70	1.58	0.42	12.1	2.70E+05	5.43
	17853	9.87	0.87	0.14	63.6	1.63E+05	5.21
	17558	5.13	0.72	0.11	41.2	1.49E+05	5.17
	13384	25.2	0.86	0.16	148	1.91E+05	5.28
	13563	8.00	1.11	0.09	73.7	8.42E+04	4.93
5/21/2003	14394	15.6	1.15	0.39	37.5	3.35E+05	5.53
	17857	8.34	0.74	0.28	27.5	3.73E+05	5.57
	13385	4.20	1.05	0.16	19.1	1.57E+05	5.20
	17853	12.6	0.66	0.10	125	1.44E+05	5.16
	17558	4.95	0.44	0.06	69.9	1.47E+05	5.17
	13384	13.0	0.79	0.11	106	1.45E+05	5.16
	13563	6.76	0.45	0.058	109	1.29E+05	5.11
6/25/2003	14394	24.6	2.03	0.77	29.2	3.81E+05	5.58
	17857	10.3	1.77	0.32	26.7	1.80E+05	5.26
	13385	13.9	1.43	0.24	52.1	1.67E+05	5.22
	17853	5.24	1.01	0.18	23.5	1.78E+05	5.25
	17558	2.53	0.56	0.089	22.2	1.58E+05	5.20
	13384	15.5	1.24	0.16	89.6	1.28E+05	5.11
	13563	4.15	0.7	0.14	24.5	2.01E+05	5.30
8/5/2003	14394	21.2	1.97	0.47	41.2	2.37E+05	5.37
	17857	14.7	1.82	0.44	29.3	2.42E+05	5.38
	13385	5.16	1.31	0.22	17.2	1.71E+05	5.23
	17853	4.70	0.79	0.16	24.2	2.05E+05	5.31
	17558	4.53	0.5	0.11	38.1	2.12E+05	5.33
	13384	5.95	0.65	0.12	46.0	1.77E+05	5.25
	13563	7.19	1.03	0.12	52.7	1.13E+05	5.05

Appendix 3. Ancillary Water Chemistry Data

Sample Site	Sample Date	Sample Time	SPM (mg/L)	Water Temperature (Centigrade)	Salinity (ppt)	pH	Dissolved Oxygen (mg/L)
Storet Number ---->			00530	00010	00480	00400	00300
17558	8/14/2002	8:55	8.16	28.6	19.3	8.06	6.20
	9/21/2002	12:00	9.1	26.4	8.4	8.65	8.60
	10/22/2002	12:35	22.1	23.1	15.9	8.21	7.67
	12/5/2002	8:04	182.4	10.8	13.7	6.99	9.31
	12/5/2002	8:04	173.8	10.8	13.7	6.99	9.31
	1/20/2003	11:20	19.9	11.7	11.5	8.12	n/a*
	2/21/2003	11:10	36.9	18.0	18.8	8.66	8.70
	4/1/2003	12:15	41.2	17.2	20.4	8.06	9.24
	5/21/2003	9:35	69.9	26.0	21.5	8.51	6.64
	6/25/2003	10:55	22.2	30.5	22.6	8.10	6.41
	8/5/2003	10:40	38.1	30.3	18.5	8.23	6.50
	8/5/2003	10:40	38.1	30.3	18.5	8.23	6.50
13384	8/14/2002	8:20	12.9	28.2	11.4	8.08	6.89
	9/21/2002	12:30	6.1	27.2	12.1	8.35	7.46
	10/22/2002	13:10	26.0	23.3	19.5	8.22	7.54
	12/5/2002	10:52	205.4	11.7	18.2	7.87	9.34
	1/20/2003	11:40	9.8	11.5	14.0	8.12	n/a*
	2/21/2003[1]	11:35	54.2	17.6	22.2	8.34	8.34
	4/1/2003	12:55	147.9	17.4	21.6	8.00	8.76
	5/21/2003	10:00	105.6	26.7	20.6	8.41	6.80
	6/25/2003	11:25	89.6	30.5	24.1	8.09	6.25
	8/5/2003	12:05	46.0	30.7	20.0	8.30	6.53
17853	8/14/2002	9:29	19.3	28.6	16.2	7.96	5.98
	8/14/2002	9:29	20.0	28.6	16.2	7.96	5.98
	9/21/2002	11:40	10.8	26.2	8.8	8.33	8.15
	10/22/2002	12:05	25.0	23.4	16.7	8.14	7.91
	10/22/2002	12:05	25.7	23.4	16.7	8.14	7.91
	12/5/2002	10:25	326.7	11.1	14.0	7.64	9.75
	1/20/2003	10:40	18.7	10.6	6.8	8.12	n/a*
	2/21/2003	10:55	19.6	16.9	19.8	8.58	9.58
	4/1/2003	11:40	63.6	16.8	20.2	7.77	9.09
	5/21/2003	9:10	125.4	26.1	18.2	8.47	6.61
	6/25/2003	10:35	23.5	30.4	24.1	8.08	6.49
	8/5/2003	11:40	24.2	30.4	17.1	8.31	6.93

Sample Site	Sample Date	Sample Time	SPM (mg/L)	Water Temperature (Centigrade)	Salinity (ppt)	pH	Dissolved Oxygen (mg/L)
13563	8/14/2002	12:35	8.2	28.6	17.6	7.98	6.26
	9/21/2002	10:45	29.9	26.5	3.5	8.39	8.14
	9/21/2002	10:45	28.6	26.5	3.5	8.39	8.14
	10/22/2002	11:15	25.8	22.4	13.5	8.08	7.56
	12/5/2002	9:30	447.9	10.9	12.4	7.22	8.00
	1/20/2003	10:00	9.9	10.4	5.7	7.99	n/a*
	1/20/2003	10:00	11.5	10.4	5.7	7.99	n/a*
	2/21/2003	9:45	19.7	17.3	16.6	8.52	9.24
	4/1/2003	10:45	73.7	16.6	16.7	8.02	8.87
	5/21/2003	8:30	108.8	25.1	11.2	8.53	7.10
	5/21/2003	8:30	111.9	25.1	11.2	8.53	7.10
	6/25/2003	10:00	24.5	30.2	19.2	8.07	6.14
	8/5/2003	11:15	52.7	30.3	11.3	8.30	6.98
13385	8/14/2002	10:40	12.4	29.0	16.7	7.95	6.05
	9/21/2002	13:00	6.4	28.0	17.8	8.17	6.28
	10/22/2002	13:45	16.2	23.4	21.2	8.27	7.66
	12/5/2002	11:18	14.3	14.8	24.6	7.86	8.15
	1/20/2003	12:10	11.6	12.0	15.6	8.26	n/a*
	2/21/2003	12:05	17.5	17.4	21.7	8.28	8.46
	2/21/2003	12:05	16.3	17.4	21.7	8.28	8.46
	4/1/2003	13:15	12.7	17.8	20.1	7.99	8.79
	4/1/2003	13:15	11.4	17.8	20.1	7.99	8.79
	5/21/2003	10:30	19.1	27.5	22.6	8.42	5.78
	6/25/2003	13:00	52.1	31.1	23.9	7.98	5.93
	8/5/2003	12:40	17.2	31.0	15.9	8.31	6.84
14394	8/14/2002	11:32	10.7	28.6	16.2	7.95	6.06
	9/21/2002	13:30	7.6	28.8	14.0	8.26	7.23
	10/22/2002	14:20	12.3	23.5	19.4	8.30	7.64
	12/5/2002	11:51	19.1	15.2	26.1	7.87	7.82
	1/20/2003	12:50	10.2	12.3	12.1	8.37	n/a*
	2/21/2003	12:45	22.1	17.9	21.5	8.18	8.07
	4/1/2003	14:00	19.0	17.9	18.5	8.03	8.62
	5/21/2003	11:10	37.5	27.3	23.2	8.32	5.80
	6/25/2003	12:10	33.2	30.5	23.7	7.96	6.18
	6/25/2003	12:10	29.2	30.5	23.7	7.96	6.18
	8/5/2003	13:25	41.2	30.8	13.6	8.14	6.69
17857	8/14/2002	11:08	25.3	28.5	14.4	7.97	6.06
	9/21/2002	13:15	9.6	28.7	xxx	8.25	6.86

Sample Site	Sample Date	Sample Time	SPM (mg/L)	Water Temperature (Centigrade)	Salinity (ppt)	pH	Dissolved Oxygen (mg/L)
	10/22/2002	14:05	16.0	23.1	20.9	8.22	6.74
	12/5/2002	11:34	16.0	23.1	20.9	8.22	6.74
	1/20/2003	12:30	7.4	11.9	13.0	8.42	n/a*
	2/21/2003	12:30	18.7	17.4	22.1	8.29	8.53
	4/1/2003	13:45	24.8	17.9	18.9	8.03	8.41
	5/21/2003	10:50	20.2	27.5	22.9	8.46	5.88
	6/25/2003	12:45	26.7	31.3	23.8	8.05	6.53
	8/5/2003	13:00	29.3	30.6	14.5	8.17	6.28