MWRA/MASCO Mercury Work Group Phase II

Mercury Management Subcommittee
Facilities Loadings Subgroup Report
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DISCLAIMER

This Report is a product of the Facilities Loadings Subgroup of the Phase II MWRA/MASCO Mercury Work Group, Mercury Management Subcommittee. All expressed opinions, suggestions, recommendations, and conclusions are those of the Subgroup and not necessarily those of any participating person or institution, including MASCO and the MWRA. The Work Group, the Subcommittee, the Subgroup, and participating persons and institutions, including MASCO and the MWRA, shall not be held responsible, individually or jointly, for any actual or consequential damages that may result from use of the information contained in this Report.

As described in the Report, certain assumptions were made by the Subgroup to produce reasonable estimates of mercury loadings to the MWRA sewer system during certain periods from specified users of the system. The Subgroup based the assumptions on existing data, good engineering practice, available standards, regulatory guidance, and its experience and expertise. Thus, no representation or warranty is made as to the accuracy of the estimated mercury loadings and other information provided in the Report.

ACKNOWLEDGMENTS

The Massachusetts Water Resources Authority (MWRA) is a public agency charged with supplying water and sewerage services to municipalities in the Boston metropolitan area. The MWRA/MASCO Mercury Work Group, a public-private partnership of the MWRA and affected dischargers, including hospitals, universities, and industries, was established in 1994 to study and implement ways to reduce mercury discharges to the MWRA sewer system. One institution, the Medical Academic and Scientific Community Organization, Inc. (MASCO) that represents many local Boston hospitals, has worked from the beginning of this effort to help identify the sources and methods of removing mercury from hospital waste streams. Phase II of the Work Group was initiated in 1996 to further examine mercury management techniques and promising mercury pretreatment technologies.

The MWRA/MASCO Mercury Work Group, Mercury Management Subcommittee, acknowledges the following participating institutions and representatives, who served as members of the Facilities Loadings Subgroup, for the significant time and resource commitment they have made in support of the Work Group process and for their contributions to the development of this report.

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1.0 EXECUTIVE SUMMARY

In its June 1995 report, the End-of-Pipe Alternatives Subcommittee in Phase I of the MWRA/MASCO Mercury Work Group concluded that 29 local hospitals discharged approximately 2 percent of the total daily mass loading of mercury to the MWRA sewer system of the Boston Metropolitan Service Area. The loadings estimate of the MWRA itself was higher because of different assumptions and data. In an effort to better understand the mercury loadings contributed by these and other similar dischargers, the Facilities Loadings Subgroup of the Mercury Management Subcommittee was formed in 1996 under Phase II of the MWRA/MASCO Mercury Work Group.

The goal of the Facilities Loadings Subgroup was to estimate known and projected mercury loadings to the MWRA Metropolitan Boston sewer system contributed by hospital and medical facilities over a two-year period. The Subgroup was also asked to reexamine the mercury loadings contributed by the 29 local hospitals studied in Phase I.

The Subgroup decided to examine five study groups of hospital-like facilities as follows: clinical laboratories, medical waste incinerators, hospital laundries, other related facilities (including college laboratories, steam suppliers, pharmaceutical manufacturers, and testing laboratories), and medical and biotech research laboratories. From a list of all MWRA permitted facilities, the Subgroup found 242 of these facilities and further determined that these facilities had a total of 355 qualifying permitted discharges or sampling locations.

We found that the sampling locations of the five study groups made significant contributions of mercury to the sewer system. We estimated that, collectively, they contributed about 50 percent of the known daily industrial mercury loadings during the two-year study period. Yet, these sampling locations discharged only about 16 percent of the estimated total daily industrial discharge flow. We also estimated that their combined mercury loadings represented about 6 or 7 percent of total mercury loadings to the sewer system while their discharge flows were only about 0.5 percent of the total treatment plant headworks flow. However, since these results are based upon a limited amount of data, we advise appropriate caution in their use.

On an individual basis, we found that a typical medical waste incinerator discharged the highest mercury loadings followed by a typical medical and biotech research laboratory. In contrast, we found that a typical clinical laboratory discharged relatively high mercury *concentrations* but relatively low mercury *loadings* because of its lower discharge flows.

In Phase I of the Work Group, the End-of-Pipe Alternatives Subcommittee had estimated that the mercury discharge loadings from 29 local hospital facilities represented between 2.6 and 3.6 percent of MWRA total system loadings during the MWRA 1995 fiscal year (FY). In this new study, our results instead suggest that the FY 1995 loadings contribution from these facilities may have been between 0.6 and 0.9 percent. For FY 1996, we estimate that their loadings contribution may have been between 1.8 and 2.5 percent of MWRA total system loadings.

Finally, we found that the total average mercury loadings discharged from the five study groups may have been between 0.02 and 0.08 pounds per day over the study period. Since this sum represents such a small quantity of mercury, one sporadic peak discharge had the potential to significantly affect the overall loadings for a particular day.[1] We observed such sporadic impacts in the discharge concentration data over the two-year study period for sampling locations within several clinical laboratory, medical waste incinerator, hospital laundry, and research laboratory facilities. During FY 1995, for example, the data suggests that a research laboratory may have discharged 0.24 pounds of mercury in one day and, during FY 1996, a hospital laundry may have discharged 0.11 pounds of mercury in one day.

[1]Readers of this report are encouraged to refer to the Work Group's Mercury Management Plan Guidance Document for recommended guidelines to address mercury management issues including the control of sporadic high mercury discharges.

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2.0 GLOSSARY OF TERMS

In this report, several terms are used that may not be familiar to many readers. For example, sewer discharges from specific types of business activities are regulated under Sewer Use Discharge Permits issued by the MWRA. Following MWRA practice, the permitted sewer discharges are called "industrial" discharges in this report.

As another example, many but not all MWRA Sewer Use Discharge Permits require the permit holders to periodically collect and analytically test representative discharge samples. In this report, discharge pollutant loadings calculated for the discharges having sample analytical data are called "known" loadings.

In addition, as described later, the Subgroup calculated overall mercury discharge concentration averages from available analytical test data for each of the five groups of facilities studied. Calculated over half-year intervals, these average concentrations are called "Group Concentration Averages (GCA's)" in this report.

These terms and several others are defined in the following Glossary of Terms. The Glossary includes definitions of each of the five study groups, the statistical term of outlier, three basic terms relating to sewage (concentration, flow, and sampling location), and two summary loadings terms (total industrial loading and total system loading).

GLOSSARY OF TERMS

Clinical Laboratories - Facilities that perform analytical testing of tissue and fluid samples from animal or human sources for medical diagnostic purposes.

Concentration - The total mass of a suspended or dissolved constituent in a unit volume of wastewater, typically expressed in units of either milligrams per liter (mg/L) or micrograms per liter (µg/L). These units are sometimes called parts per million (ppm) and parts per billion (ppb), respectively.

Discharge Loading - The total mass of a suspended or dissolved constituent in a wastewater discharge over a fixed period, typically expressed in units of pounds per day (lbs/day). It can be calculated by multiplying a measured concentration value by an associated flow value and an appropriate units conversion factor.

Flow - A volume of liquid per unit time, typically expressed for wastewater discharges in units of gallons per day (gpd).

Group Concentration Average (GCA) - In this study, the average mercury concentration for a specified group of discharges calculated by averaging individual discharge concentration averages.

Hospital Laundries - Facilities that directly serve a hospital in the laundering of linens, gowns, and lab coats.

Known Discharge Loading - A discharge loading for an MWRA permitted sampling location that has both concentration test data and a measured or estimated flow.

Medical Waste Incinerators - In this study, facilities that burn hospital waste or medical/infectious waste and use a wet scrubber for reducing air pollutant emissions.

Other Facilities - In this study, facilities that perform any hospital-like function. Such facilities included college laboratories, steam suppliers, pharmaceutical manufacturers, and testing laboratories.

Outlier - An unusually high or low value in a data set, typically identified by comparison to a statistical limit.

Research Laboratories - In this study, facilities that conduct medical or biotechnology research.

Sampling Location - An industrial waste sewer discharge point, defined in a MWRA Sewer Use Discharge Permit, at which representative waste samples are collected for analysis.

Total Industrial Loading - The total mass of a suspended or dissolved constituent discharged in all MWRA permitted sewer discharges over a fixed period, typically expressed in units of pounds per day (lbs/day). It can be calculated by determining the sum of individual Known Discharge Loadings (see above for definition).

Total System Loading - The total mass of a suspended or dissolved constituent contained in sewage that enters a sewer system or municipal treatment plant over a fixed period, typically expressed in units of pounds per day (lbs/day). It can be calculated by multiplying a measured treatment plant influent concentration value by an associated flow value.

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3.0 STUDY ASSUMPTIONS AND METHODOLOGY

The members of the Facilities Loadings Subgroup agreed that:

- We would select facilities for an expanded discharge loadings study that fell into the following groups:

    1. Clinical Laboratories
    2. Incinerators (medical waste)
    3. Laundries (hospital)
    4. Other (college laboratories, laboratory suppliers, steam suppliers, pharmaceutical manufacturers, and various testing laboratories)
    5. Research Laboratories (medical and biotech)

    We chose these types of facilities for the study because we believed that their operations and discharges would be similar to those of hospitals. We selected the facilities manually by reviewing a list of all currently MWRA-permitted industrial dischargers. The final list of selected facilities consisted of 242 facilities.

- We would attempt to accurately estimate wastewater discharge flow at each sampling location within the 242 selected facilities by using a questionnaire that would be mailed to the facilities. For any sampling locations having a wastewater flow meter, we would use averaged metered flow rates as shown in questionnaire responses. For other sampling locations in clinical, research or other laboratory facilities, we would use a discharge flow model. To obtain input into this model, we would ask in the questionnaire for numbers of fixtures (defined as laboratory sinks and fume hood (cup) sinks), numbers of glass washers and photoprocessors, and estimated flow contributions of discharges from water treatment systems, non-contact cooling water uses, and sanitary wastewater sources. We could also use the indicated sizes of final pH adjustment or limestone chip tanks in our model.

    To simplify the questionnaire and the study, we would ask only for current facility configuration information. As a result, we would assume that our estimated wastewater discharge flow for each sampling location was fixed over our study period.

    For non-respondents to our questionnaire, we would use the discharge flow estimates (provided by the facilities) that appeared in MWRA permitting and inspection records. In addition, we would use the questionnaire responses to help us allocate each identified sampling location into the proper group: Clinical, Incinerator, Laundry, "Other," or Research. We found that several larger facilities had multiple sampling locations belonging to two or more of the five study groups.

- We would take mercury concentration test data for the designated sampling locations from the MWRA laboratory report database. We would include quality-control checked analytical test data from:

    - MWRA-collected discharge samples tested by an MWRA-contracted analytical laboratory or by the MWRA Central Laboratory both of which are certified by the Massachusetts Department of Environmental Protection (MADEP).

- Self-monitoring discharge samples tested by contract analytical laboratories certified by the MADEP. (These laboratories electronically report their test results to the MWRA).

- We would use a two-year study period corresponding to MWRA fiscal years 1995 and 1996, *i.e.*, July 1, 1994 to June 30, 1995 and July 1, 1995 to June 30, 1996, respectively. Fiscal Year 1995 was included in the Phase I study of 29 hospitals. To observe any trends in discharged mercury concentrations from the entire 242 facilities of this study and from the 29 Phase I hospitals, we would break the study period into four half-year intervals.
- For each sampling location, we would calculate average concentrations of mercury over each half-year interval from available discharge sampling concentration data. For sample results having non-detect values, we would do two calculations. We would estimate a minimum average mercury concentration when we set all individual non-detect values equal to 0.0 micrograms per liter (µg/L). The concentration units of µg/L are often called "parts per billion" (ppb).

  Then, we would estimate a maximum average mercury concentration when we set all individual non-detect values equal to the stated detection limits (typically, 0.2 to 1.0 µg/L (ppb)). In this way, we could find a range of possible discharge mercury concentration averages for each sampling location to provide insight into expected accuracy of our calculations.

- To help show the extent and quality of the analytical test database, we would examine the numbers of sample test results contributing to the individual half-year mercury concentration averages in each half-year interval at each sampling location. We found that the numbers of samples varied from one sample to 28 samples. The number of samples at a sampling location depended upon specific permit requirements for self-monitoring and MWRA monitoring schedules. Clearly, for a particular sampling location, more representative half-year mercury concentration averages would be derived from larger numbers of sample test results.
- For each sampling location, we would calculate two mercury discharge mass loading averages for each half-year interval by multiplying our fixed wastewater discharge flow estimate by the corresponding minimum and maximum mercury concentration averages. Then, we would allocate and sum the individual discharge mass loading averages to find overall mercury loadings discharged from each of the five groups of facilities.
- For sampling locations that had no test data for mercury, we would calculate "group average" half-year discharge mercury concentrations from all available data within each study group. Then, to estimate the individual half-year mercury discharge loadings from sampling locations without specific mercury test data, we would multiply the proper group average mercury concentrations by the individual discharge flow estimates.
- We would then sum all mercury discharge loadings by study group and compare the group totals against available MWRA estimates of total industrial and system-wide mercury loadings.
- Lastly, extracting applicable data from the above loadings calculations, we would review mercury discharge loadings for the 29 Phase I hospitals to compare our study results with the June 1995 Phase I findings and to observe any subsequent changes.

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4.0 WASTEWATER FLOW QUESTIONNAIRE

As outlined above, we prepared and mailed Questionnaires to 242 selected facilities. A copy of the Questionnaire form is included in Appendix A. We received responses from 160 facilities, representing a response rate of about 66 percent. This high response rate may be related to the convenience offered by the return envelopes that we included in the mailing and to the follow-up telephone calls that we made to several non-responding large dischargers (with flows greater than 1,000 gpd).

From several facilities, the responses included multiple completed Questionnaires for permitted sampling locations belonging to two or more of the five study groups. Based upon the Questionnaire responses and subsequent reviews of MWRA permitting records, we found that the quantities of sampling locations in the five study groups were as follows:

Facility Group	Number of Sampling Locations
Clinical	64
Incinerator	3
Laundry	10 *
Other	85
Research	193
Total	355

* Two locations ended Laundry operations late in FY 1995 so that the number of Laundry sampling locations for FY 1996 was eight.

Our goal was to generate accurate estimates of wastewater discharge flows for all identified sampling locations. For accurate discharge flow estimates, we used flow rates from wastewater flow meters installed in 39 sampling locations as shown in the Questionnaire responses. For unmatured sampling locations in clinical, research, or other laboratory facilities, we decided to use a discharge flow model.
To obtain input for this model for each sampling location, we asked in the Questionnaire for:

1. Numbers of connected fixtures (*i.e.*, laboratory sinks and fume hood (cup) sinks),
2. Numbers of connected glass washers,
3. Numbers of connected photoprocessors, and
4. Estimated flow contributions from any water treatment systems discharges,[2] non-contact cooling water discharges[3], and sanitary wastewater discharges.
5. Sizes of final pH adjustment or limestone chip tanks.

For Questionnaires with incomplete responses and for all non-respondents, we used discharge flow estimates reported by the facilities that appeared in MWRA permitting and inspection records.
The model we used for discharge flow estimating was based upon a unit fixture flow rate and upon indicated numbers of laboratory sinks and fume hood (cup) sinks in returned Questionnaires. We initially intended to use a unit laboratory fixture flow rate of 10 gallons per hour that is the applicable design rate specified in the Massachusetts Plumbing Code[4]. However,

we decided to perform a back-calculation of unit flow rates when we received 14 returned Questionnaires that included both wastewater flow meter values and responses for items 1.- 4. above. The number of fixtures for these 14 sampling locations varied from five fixtures to 1,000 fixtures. Of the 14 back-calculated unit fixture flow rates, eight (or 53 percent) were between 3.0 and 7.0 gallons per hour assuming an eight-hour operating day.

We found good conformance to the 14 reported flow meter readings when we used a unit flow rate of 10 gallons per hour each up to 30 fixtures and 5 gallons per hour each in excess of 30 fixtures for eight hours per day. In addition, we arbitrarily used 100 gpd as the estimated daily discharge flow from glass washers and 60 gpd from photoprocessors (based upon a rinse water replenishment rate of 0.5 gallons per minute for two hours of use per day). Therefore, the model we used to estimate discharge flow was as follows:

Estimated Flow (gpd) = (No. of Fixtures) x 10 gallons per hour x 8 hours per day

(Up to 30 Fixtures)

+ (No. of Fixtures) x 5 gallons per hour x 8 hours per day

(Over 30 Fixtures)

+ (No. of Glass Washers) x 100 gpd

+ (No. of Photoprocessors) x 60 gpd

+ Sanitary Loads Connected (gpd)

+ Water Treatment Loads Connected (gpd)

+ Non-Contact Cooling Water Loads Connected (gpd)

Since we made about 140 discharge flow estimates (about 40 percent of the sampling locations studied) using this model, the validity of the model was important. For the 14 sampling locations that responded with both metered discharge flow rates and fixture count information, we found that the flow estimates produced by the model equation were less than 15 percent greater on average than the metered values. Therefore, we were satisfied that the model had validity and would produce sufficiently accurate discharge flow estimates for this study.

For flow estimates based only upon neutralization vessel or limestone chip tank size, we assumed an eight-hour operating day and a 30 minute wastewater residence time in the tank. Since most of the returned Questionnaires included fixture count information and the neutralization tank assumptions were quite rough, we were pleased that only five discharge flow estimates had to be made using this method.

Table A, entitled Wastewater Flow: Questionnaire Data and Calculations, appearing in Appendix A, shows the data from returned questionnaires as a spreadsheet, the laboratory flow model results, and the final selected flow estimate for each sampling location. For each study group, the table shows that total estimated flows were approximately as follows:

Study Group	Number of Sampling Locations	Total Estimated Discharge Flow (Rounded to nearest 1,000)
Clinical	64	218,000 gpd
Incinerator	3	7,000
Laundry	10 *	109,000 *
Other	85	321,000

Research	193	1,400,000	
Grand Total	355		**2,055,000 gpd**

* Two locations ended Laundry operations late in FY 1995 so that the estimated total Laundry discharge flow for FY 1996 was about 68,800 gpd.

We assumed that these estimated flows were constant over the entire FY 1995 and FY 1996 study period. To confirm the Questionnaire responses and model results, we reviewed discharge flow estimates reported by the facilities that appeared in MWRA permitting and inspection records. Our review showed that the reported discharge flow estimates exceeded those of the model for about two-thirds of the facilities. This was an expected result since it is evidently common practice for facilities to overestimate their discharge flows for discharge permitting purposes. While our model produced lower flow estimates in many cases and thus lower mercury loadings estimates, we believe that the overall results of these estimates are valid for each group of facilities.

In the 1992 Local Discharge Limits Development Report prepared for the MWRA, PEER Consultants had estimated that the discharge flow from all permitted industrial discharges was about 12.6 million gallons per day (MGD). While PEER examined flow data from an earlier period and we used a different method to estimate discharge flows, it is of interest that our estimated discharge flow of 2,055,000 gpd (or 2.05 MGD) for all five study groups may represent only about 16 percent of the total permitted industrial discharge flow to the MWRA Metropolitan Boston sewer system.

[2]It should be noted that MWRA regulations - 360 CMR 10.023 (19) - require that any water treatment filter backwashes be specifically authorized and meet all regulated limits and prohibitions.

[3]It should also be noted that discharges of non-contact cooling water to the MWRA sewer system are prohibited (with some exceptions) per MWRA regulations - 360 CMR 10.006 (2) and 10.023 (2).

[4]Massachusetts regulations 248 CMR 2.13.

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5.0 DISCHARGE MERCURY CONCENTRATION DATA

We extracted mercury concentration test data for all permitted discharges from the MWRA Laboratory Information Management System for MWRA Fiscal Years (FY) 1995 and 1996. FY 1995 began on July 1, 1994 and ended on June 30, 1995. Similarly, FY 1996 began on July 1, 1995 and ended on June 30, 1996. We exported the test data into a personal computer spreadsheet program where we sorted the data and matched it to the facilities selected for the study.

For each sampling location, we then used the spreadsheet program to calculate average mercury concentrations for each half-year period of the two fiscal years under study. That is, we calculated average mercury concentrations for four six-month periods beginning June 1994, January 1995, June 1995, and January 1996. In the calculations, we handled all non-detected sample results (also known as below detection limit (BDL) results) in two distinct ways:

- We considered each calculated average mercury concentration to be at a minimum value if all individual non-detects were taken to be 0.0 µg/L (ppb).
- We considered each calculated average mercury concentration to be at a maximum value if all individual non-detects were taken at the stated detection limits (typically, 0.2 µg/L to 1.0 µg/L (ppb)).

In this way, a possible range of calculated mercury concentration averages for each sampling location could be determined and could possibly provide insight into expected accuracy of the calculations. We also showed in the spreadsheet the number of sample data points contributing to each average. As shown, mercury concentration averages were often derived from only one data point but could be derived from as many as 28 data points.
We sorted the individual sampling locations and their mercury concentration averages into the five groups: Clinical, Incinerator, Laundry, Other, and Research. For each of the five groups, we calculated overall average concentrations for each half-year interval. These overall averages, hereinafter called *Group Concentration Averages* (GCA's), were calculated after two rounds of data censoring.
We used a commonly-accepted statistical analysis technique as follows:

- In the first censoring round, we examined individual sampling locations and half-year intervals having multiple data points. We assumed that the concentration data had a Normal Distribution and tested the data for outliers. Outliers are unusually high or low values that sometimes result from one-time events at a facility or from sampling or testing errors. We used a standard test for outliers by applying an upper limit as follows:

  Upper Limit = Average + 3 x Standard Deviation.

  This limit would include about 99.7 percent of all normally distributed data. We believed that this conservative upper limit would eliminate the dominant effects of very high discharge concentration measurements in the individual averages.

- In the second censoring round, we similarly looked for outliers in the assembly of individual average mercury concentrations within each group for each half-year interval. We calculated the initial group half-year averages and applied the Normal Distribution upper limit as above to remove outliers from the individual mercury concentration averages. In this way, we reduced the dominant effects of any high individual averages. Thus, our GCA's were the post-outlier group averages of individual mercury concentration averages.

It is important to note that we censored the mercury concentration data only for purposes of calculating the *Group Concentration Averages* (GCA's). We calculated all individual facility loadings estimates using mercury concentration averages derived from totally uncensored data. The mercury concentration data and averages for Fiscal Year 1995 are presented in Table B-1 of Appendix B. Mercury concentration data and averages for Fiscal Year 1996 are presented in Table B-2 of Appendix B. To produce these tables, we first sorted the data into the five study groups and then by MWRA Facility Identification Numbers and Sampling Location Numbers. The tables show that we averaged any duplicate concentration test results for a single date before using them in our calculations of averages for the respective half-year interval. The tables also show the number of samples test results that made up each concentration average.

At the end of each group listing in the tables, we presented statistical summaries that show overall mercury concentration averages, numbers of samples and tested sample locations, the normal distribution 99.7 percent upper limits, and the mercury concentration averages after removal of outliers. These post-outlier averages are the *Group Concentration Averages* (GCA's). We also provided the total number of samples tested for each group. In addition, the average number of samples per sampling location is shown for each half-year interval.

As an example, page 9 of Table B-1 shows that 22 sampling locations of our 64 Clinical facilities had mercury concentration data in the first half-year of FY 1995. There were 101 samples tested for mercury, averaging a respectable 4.6 samples per sampling location. The "minimum" and "maximum" Clinical concentration averages were 3.22 µg/L and 3.44 µg/L (ppb). After removal of outliers, the Clinical GCA's became 1.35 µg/L and 1.58 µg/L (ppb). Thus, the overall average mercury concentrations for Clinical discharges were lowered by nearly 60 percent through the censoring of outliers in both raw concentration data and individual averages.

The following tabulation summarizes the numbers of sample test results used to calculate the respective GCA's:

	FY 1995			**FY 1996**	
1st Half		**2nd Half**	**1st Half**		**2nd Half**
101	Clinical	102	86	Clinical	78
5	Incinerator	16	19	Incinerator	8
34	Laundry	30	16	Laundry	9
26	Other	34	51	Other	25
167	Research	222	237	Research	201
333		404	412		221

We believe that the censoring of outliers was an important part of our methodology for estimating the group mercury loadings. We used the resulting GCA's within each study group to calculate mercury discharge loadings for sampling locations that had no mercury concentration test data. We believe that, with this approach, we have made reasonable total loadings estimates for the identified groups of clinical, incinerator, laundry, other, and research dischargers. We have summarized the GCA's in Table 1 for FY 1995 and Table 2 for FY 1996.

The two tables also show the numbers of sampling locations having mercury concentration data in each of our five study groups for each half-year interval. Adding these numbers, we find that the numbers of sampling locations having mercury concentration data in our five study groups for FY 1995 were 92 in the first half-year and 117 in the second half-year. For FY 1996, the corresponding numbers were 116 in the first half-year and 124 in the second half-year. Dividing these numbers into the associated total number of tested samples from the above tabulation, we can see that about 3.5 samples were tested per sampling location for each half-year period

except for the second half-year period of FY 1996 when only 1.8 samples were tested per sampling location. The reason for this falloff in sampling is beyond the scope of this study.
From another perspective, we had actual mercury concentration data for 35 to 51 percent of Clinical sampling locations, 19 to 23 percent of Other sampling locations, and 23 to 38 percent of Research sampling locations. Incinerator and Laundry sampling locations had higher percentages. Thus, the GCA's for each study group allowed us to estimate mercury discharge loadings for the majority of sampling locations that did not have concentration data.
In addition, for many locations that had concentration data, there were only one or two available sample test results with which to calculate mercury concentration averages. Clearly, our study would have benefited from the availability of more concentration data.

TABLE 1
FY1995
Group Concentration Averages (GCA's)
ug/L (ppb)

1ST HALF Min	**Max**	**2ND HALF Min**	**Max**
Clinical Group : (22 Locations)		(31 Locations)	
1.35	1.58	2.63	2.96
Incinerator Group : (3 Locations)		(3 Locations)	
86.28	86.34	27.95	28.04
Laundry Group : (5 Locations)		(7 Locations)	
0.35	0.53	0.10	0.61
"Other" Group : (19 Locations)		(17 Locations)	
0.23	0.82	1.08	1.46
Research Group : (43 Locations)		(59 Locations)	
0.79	1.20	2.24	2.82
Overall: 92 Sampling Locations with data.		**Overall:** 117 Sampling Locations with data.	

TABLE 2
FY1996
Group Concentration Averages (GCA's)
ug/L (ppb)

1ST HALF Min	Max	2ND HALF Min	Max
Clinical Group: (32 Locations)		(30 Locations)	
1.24	1.62	3.84	4.20
Incinerator Group: (3 Locations)		(3 Locations)	
69.79	70.04	232.20	232.24
Laundry Group: (6 Locations)		(5 Locations)	
0.94	1.52	0.94	1.44
"Other" Group: (15 Locations)		(15 Locations)	
1.25	1.45	0.68	0.71
Research Group: (60 Locations)		(71 Locations)	
1.19	1.61	1.44	1.83
Overall: 116 Sampling Locations with data.		**Overall:** 124 Sampling Locations with data.	

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6.0 MERCURY LOADINGS CALCULATIONS

We prepared two spreadsheets that list the uncensored minimum and maximum half-year mercury concentration averages for each sampling location along with the associated discharge flow estimates. Fiscal Year 1995 mercury loadings are presented in one spreadsheet identified as Table C-1 in Appendix C. FY 1996 mercury loadings are presented in the other spreadsheet identified as Table C-2 in Appendix C.

In the spreadsheets, we calculated mercury discharge loadings for each sampling location by multiplying mercury concentration averages by the associated flow estimates. As detailed above, we inserted the applicable minimum and maximum half-year *Group Concentration Averages* (GCA's) into the spreadsheets for locations that did not have any mercury discharge concentration data.

As shown on Page 4 of Table C-1, for example, 22 Clinical sampling locations had mercury concentration data for the first half-year of FY 1995 out of 64 total Clinical sampling locations (about 34 percent). Because the other sampling locations had no test data, we used the appropriate Clinical GCA's to estimate their mercury discharge loadings. For the second half-year of FY 1995, the Clinical GCA's were based upon 30 of the overall 64 Clinical locations (about 47 percent). Since the numbers of locations contributing to these GCA's were statistically significant, we expect this overall loadings estimating method to be valid.

Page 4 of Table C-1 also shows the total Clinical daily discharge flow and half-year minimum and maximum mercury loadings in milligrams per day, pounds per day, and pounds per year. Based upon the total Clinical discharge flow and mercury loadings, equivalent discharge mercury concentrations are shown. For insight into the effects of the highest individual discharge loadings, the table also shows for each half-year period:

- the fractions contributed by the maximum mercury loadings expressed as percentages of the overall Clinical loadings, and

- overall Clinical loadings in pounds per day after subtracting the individual maximum loadings.

As shown on Page 11 of Table C-1, only about 15 percent of the Other study group (13 to 14 locations of the entire 85 Other locations) had mercury test data in FY 1996. This group had the smallest percentage of locations having mercury test data. In general, the absence of extensive mercury test data is the result of Sewer Discharge Permits that do not require frequent discharge sampling and measurement of mercury concentrations. The resulting loadings estimates can be considered as less reliable for the locations and half-year periods having high percentages of locations where we had to use GCA's instead of specific actual mercury concentration data. Thus, it is possible that the reliability of the overall Other group loadings estimates was lower than that of the other groups. Overall, however, we regard the GCA's as representative of the minimum and maximum half-year mercury discharge concentrations of each respective study group.

We have summarized the estimated mercury discharge loadings in Table 3 for FY 1995 and Table 4 for FY 1996. The discharge loadings are also presented graphically in Figure 1 for FY 1995 and Figure 2 for FY 1996.

As we examine these discharge loadings tables and figures, we see that the Research group discharged the highest mercury loadings during FY 1995. In the second half-year, the Research group loadings significantly increased. As shown in the summary section for Research facilities in Table C-1, one Research location contributed about 35 to 40 percent of the total group mercury

loadings for that period. In turn, the overall Research group was responsible for more than 80 percent of the total mercury discharge loadings of all five study groups.
Mercury discharge loadings of the Clinical and Other groups were comparable in FY 1995 and both were higher in the second half-year. The Incinerator group, consisting of only three sampling locations, contributed larger mercury loadings than the Laundry group with ten sampling locations.
The results for FY 1996, however, were quite different. Overall, mercury discharge loadings from all groups were higher than those for FY 1995, except the second half-year loadings of the Research group. In FY 1996, the Laundry group was responsible for peak loadings in the first half-year that were higher than 0.03 pounds per day. In this case, however, one Laundry location was responsible for more than 95 percent of the group mercury loadings. As shown on Page 11 of Table B-2, two samples of a total of six samples collected at that Laundry location produced an average mercury test concentration of nearly 400 µg/L (ppb).

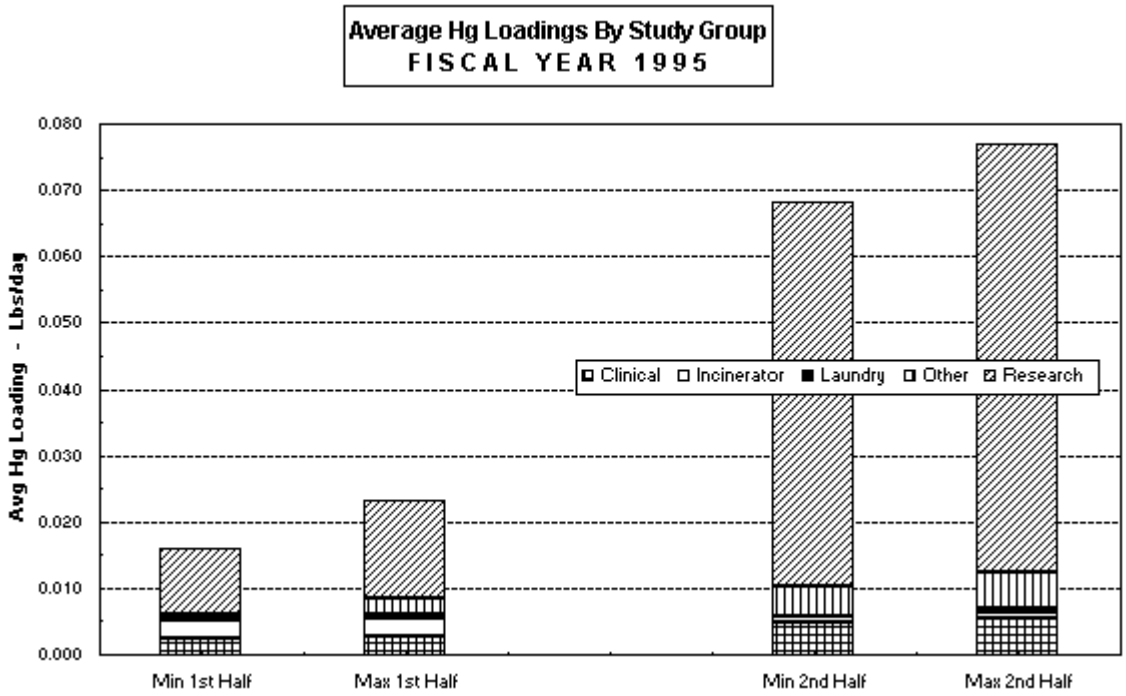

FIGURE 1

TABLE 3
FY1995
Total Mercury Loadings

	Minimum 1st Half	Maximum 1st Half	Minimum 2nd Half	Maximum 2nd Half	
	Lbs/Day	**Lbs/Day**	**Lbs/Day**	**Lbs/Day**	**No. of Locations**
Clinical	0.002	0.003	0.005	0.006	64
Incinerator	0.003	0.003	0.001	0.001	3
Laundry	0.0003	0.0004	0.0001	0.0006	10
Other	0.001	0.003	0.005	0.005	85
Research	0.010	0.015	0.058	0.065	193
TOTALS	**0.016**	**0.023**	**0.068**	**0.077**	**355**

	Lbs/Day	Lbs/Day	Lbs/Day	Lbs/Day	

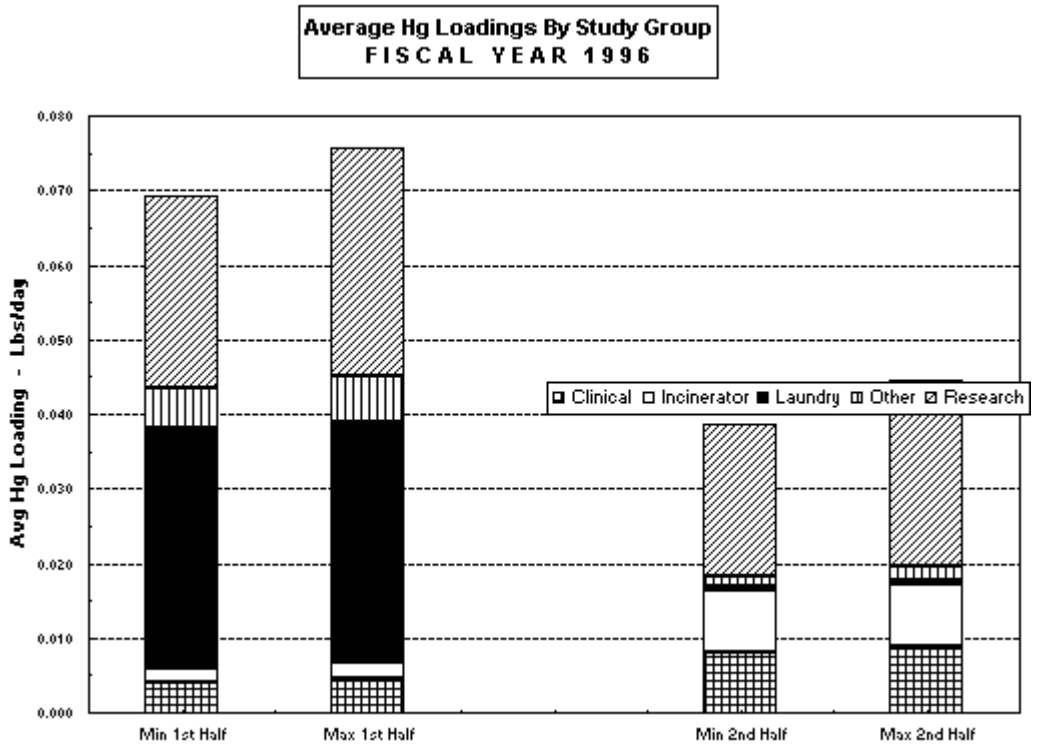

FIGURE 2

TABLE 4
FY1996
Total Mercury Loadings

	Minimum 1st Half	Maximum 1st Half	Minimum 2nd Half	Maximum 2nd Half	
	Lbs/day	**Lbs/day**	**Lbs/day**	**Lbs/day**	**No. of Locations**
Clinical	0.004	0.005	0.008	0.009	64
Incinerator	0.002	0.002	0.008	0.008	3
Laundry	0.0320	0.0322	0.0006	0.0008	8
Other	0.005	0.006	0.001	0.002	85
Research	0.026	0.031	0.020	0.025	193
TOTALS	**0.069 Lbs/day**	**0.076 Lbs/day**	**0.039 Lbs/day**	**0.045 Lbs/day**	**353**

Note: In FY 1995, there were 10 Laundry sampling locations.

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7.0 COMPARISONS OF OVERALL RESULTS

7.1 Introduction

In this section, we compare the estimated mercury loadings from the five study groups to the MWRA total known industrial (permitted) loadings and to the MWRA total system loadings. We also present normalized mercury discharge loadings for each of the five study groups to simplify comparisons between the study groups.

The MWRA total known industrial (permitted) mercury loadings are the loadings contributed by all industries that are monitored for mercury. The monitoring data consists of flow estimates and analytical test results from self-monitoring events and MWRA monitoring events.

The MWRA total system loadings include mercury loadings from all sources including permitted industrial discharges, unpermitted residential and commercial discharges, and ambient sources (such as groundwater infiltration into sewer pipes and rainwater runoff in combined sewer areas). The total system loadings are calculated using flow and concentration data from influent monitoring at the MWRA Deer Island and Nut Island treatment plants.

7.2 Overall Results Comparisons - Total Industrial Loadings

The MWRA maintains nearly 1,100 sewer use discharge permits for facilities in the Boston Metropolitan Sewer Service Area. Therefore, the 242 facilities studied represent an important 22 percent of all MWRA-permitted facilities.

The MWRA uses a computer program, known as TRAC-IS, to track and monitor the compliance record of its permitted sewer users. Through TRAC-IS, the MWRA can produce an estimate of the overall "known" industrial mercury discharge loading from all permitted sampling locations. TRAC-IS calculates loadings for only those sampling locations that have database entries for both discharge flow and concentration test data. This is the reason that we used the word "known" in the first sentence of this paragraph.

In our study, we calculated *Group Concentration Averages* (GCA's) for sampling locations in each of the five study groups that had mercury concentration test data. We then estimated mercury discharge loadings for sampling locations that did not have mercury concentration test data by using the GCA's. To compare our results with the known industrial mercury discharge loadings, therefore, we must subtract out all loadings calculated from GCA's to determine our own "known" loadings.

For FY 1995, our known study group mercury loadings are presented in a spreadsheet identified as Table D-1 in Appendix D. Our known FY 1996 study group mercury loadings are presented in a spreadsheet identified as Table D-2 in Appendix D.

For the full year of FY 1995, we found that our estimated known average mercury discharge loading from all five study groups was about 0.009 pounds per day (first half) and 0.047 pounds per day (second half) for an overall average of approximately 0.028 pounds per day. Similarly for all of FY 1996, our estimated overall known loading average was about 0.042 pounds per day. In contrast, we noticed from available TRAC-IS reports that the overall known industrial mercury sewer discharge loadings were about 0.053 pounds per day in FY 1995 and 0.081 pounds per day in FY 1996.[5]

Thus, our five study groups possibly contributed 53 percent (0.028/0.053 x 100) of the FY 1995 overall known industrial mercury loading to the sewers. Similarly, our study groups possibly contributed 52 percent (0.042/0.081 x 100) of the FY 1996 overall industrial loading.

Since our five study groups appeared to contribute about 50 percent of the known industrial mercury loadings while discharging only about 16 percent of the estimated total industrial discharge flow, they may be relatively significant industrial (permitted) contributors of mercury to the Boston Metropolitan Sewer Service Area. In Section 7.4 of this report, we break down the percentage contributions of the individual study groups to the total known industrial loadings.

In Table 3, we showed that the total estimated loadings from the five study groups were from 0.016 pounds per day (minimum first half) to 0.077 pounds per day (maximum second half). If we take the average for the year as 0.046 pounds per day, we could say that our FY 1995 "known" estimated average loading of 0.028 pounds per day was about 60 percent of the corresponding total estimated loadings of the five study groups. Similarly, from Table 4, we could calculate the total estimated loadings for FY 1996 as 0.057 pounds per day. Thus, the "known" estimated loadings of 0.042 pounds per day represent about 70 percent of our corresponding total estimated loadings of the five study groups. These percentages tell us that most of the loading estimates for both FY 1995 and FY 1996 are based upon specific sampling location concentration data.

These percentages are unexpectedly high considering the relatively few numbers of sampling locations that had available mercury concentration test data. The percentages reflect, therefore, the likelihood that sampling locations with large discharge flows (and thus large loadings) would have mercury concentration test data.

7.3 Overall Results Comparisons - Total System Loadings

For its Industrial Waste Report No. 12, dated October 1996, the MWRA prepared estimates of mercury loadings in the sewage received at treatment plant headworks from the sewer system of the Metropolitan Boston Service Area. The mercury loadings received at the treatment plant are called total system loadings and are calculated daily by multiplying measured concentrations by the associated daily flow and an appropriate units conversion factor. The MWRA estimates were 0.77 pounds of total mercury per day in FY 1995 and 0.83 pounds per day in FY 1996. The MWRA also estimated that the average treatment plant headworks flows were about 390 MGD in FY 1995 and 430 MGD in FY 1996.[6]

For comparison, our overall loadings estimates for the five study groups, derived by averaging the minimum and maximum loadings over both half-year periods, were 0.046 pounds per day in FY 1995 and 0.057 pounds per day in FY 1996. In addition, we estimated that our five study groups discharged about 2.05 MGD.

Therefore, the mercury loadings contributions from all five study groups were about 6 percent in FY 1995 and 7 percent in FY 1996 of total headworks mercury loadings. These loadings contributions were made by wastewater discharge flows that represented only about 0.5 percent of the total treatment plant headworks flow.

7.4 Overall Results Comparisons - Study Group Contributions

Broken down by study group and averaged for estimated minimum and maximum mercury loadings over each of the two years of our study, the percentage contributions of our five study groups to total industrial discharge mercury loadings and MWRA total sewer system mercury loadings were approximately as follows:

TABLE 5

STUDY GROUP PERCENTAGE CONTRIBUTIONS

Facility Groups (No. of Sampling Locations)	Known Mercury Discharge Loadings Averages as % of Total Known Industrial Discharge Loadings		Overall Mercury Discharge Loadings Averages as % of Total System Loadings	
	FY 1995	FY 1996	FY 1995	FY 1996
Clinical (64)	4.5%	6.0%	0.5%	0.8%
Incinerator (3)	3.4%	6.3%	0.2%	0.6%
Laundry (10 / 8)	0.4%	20.1%	0.05%	2.0%
Other (85)	3.4%	2.5%	0.4%	0.4%
Research (193)	41.5%	16.8%	4.8%	3.1%
Totals (355 / 353)	53.2%	51.6%	6.0%	6.9%

7.5 Overall Study Results - Normalized

Normalized mercury discharge loadings for each type of study group can be of help in judging the expected loadings from one individual discharge. For normalization, we calculated average mercury loadings for each study group by taking known loadings totals and dividing by the numbers of associated sampling locations. We elected to express the average mercury loadings in units of pounds per day per 100 sampling locations to avoid dealing with very small numerical loadings values.

Tables 6 and 7 summarize the normalization results for FY 1995 and FY 1996, respectively. The bar charts of Figures 3 and 4, respectively, present the information graphically.

Ranked by highest-to-lowest average mercury loadings for the five study groups, the FY 1995 results show that individual discharges could be listed in the following order:

1st - Incinerator (1st half) or Research (2nd half)

2nd - Research (1st half) or Incinerator (2nd half)

3rd - Other

4th - Clinical

5th - Laundry.

The low ranking of Clinical facilities is somewhat surprising since it was believed from the work of the Phase I Work Group that Clinical facilities would rank high as potential sources of mercury discharge loadings. The reality may be that Clinical facilities, while possibly having wastewater discharges with significant *concentrations* of mercury, may have relatively low individual discharge flows that serve to produce low *loadings* of mercury.

For FY 1996, the average loadings rankings varied from the first half-year to the second half-year. This phenomenon is attributable to individual high discharge concentrations in one of the half-year periods. Ranked by highest-to-lowest average mercury loadings by study group, the FY 1996 results show that individual discharges could be listed in the following order for the first half-year:

1st - Laundry (first by an order of magnitude)
2nd - Incinerator
3rd - Research
4th - Other
5th - Clinical facilities

The Laundry ranking as first in average mercury loadings (at about 0.5 pounds per day per 100 sampling locations) could have been expected from the very high loadings of one facility during the first half-year period of FY 1996.

For the second half-year of FY 1996, the results show that the ranking order would be:

1st - Incinerator (first by an order of magnitude)
2nd - Clinical
3rd - Research
4th - Laundry
5th - Other

Except for the second place ranking of the Clinical group, this order is similar to that of all of FY 1995. As shown on Page 4 of Table D-2, one sampling location in the Clinical group contributed about 60 percent of the estimated known group loadings for the second half-year period of FY 1996. This high loadings contribution may have been responsible for the elevated ranking of the Clinical group for the period.

From this brief review of normalized discharge loadings, we have gained some insight into expected loadings from a typical study group facility. We also found that the mercury concentration and the discharge flow are equally important factors in a discharge loading value. Because of observed variabilities in the normalized discharge loadings, however, we recommend that normalized loadings be calculated for additional half-year periods to gain a better understanding of possible overall study group rankings and long-term trends.

TABLE 6 FY1995
Average Mercury Loadings
Per 100 Locations
(see Figure 3)

GROUP	Minimum 1st Half	Maximum 1st Half	Avg 1st Half	Rank * 1st Half	Minimum 2nd Half	Maximum 2nd Half	Avg 1st Half	Rank * 2nd Half	No. of Tested Locations
	Lbs/Day	Lbs/Day	Lbs/Day		Lbs/Day	Lbs/Day	Lbs/Day		1st Half / 2nd Half
CLINICAL:	0.006	0.007	**0.006**	**(4)**	0.011	0.012	**0.012**	**(4)**	22 / 30

INCINERATOR:	0.090	0.090	**0.090**	**(1)**	0.030	0.030	**0.030**	**(2)**	3 / 3
LAUNDRY:	0.003	0.005	**0.004**	**(5)**	0.001	0.006	**0.004**	**(5)**	5 / 7
OTHER:	0.001	0.008	**0.005**	**(3)**	0.020	0.022	**0.021**	**(3)**	13 / 14
RESEARCH:	0.009	0.011	**0.010**	**(2)**	0.067	0.071	**0.069**	**(1)**	40 / 58

* Rankings by loadings values

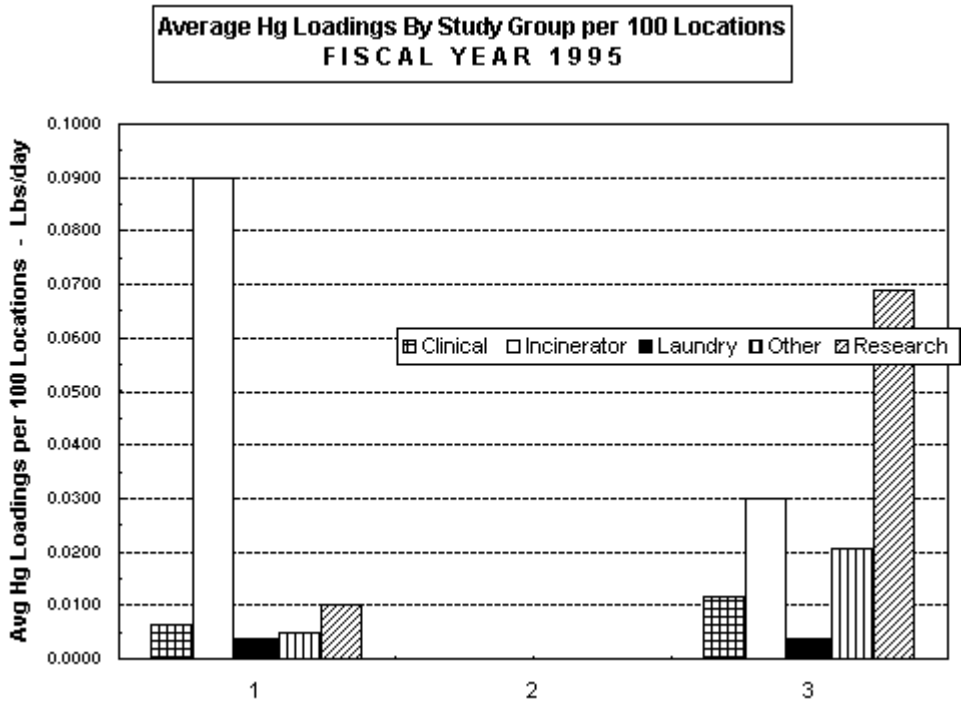

FIGURE 3

TABLE 7 FY1996
Average Mercury Loadings
Per 100 Locations
(see Figure 4)

GROUP	Minimum 1st Half	Maximum 1st Half	Avg 1st Half	Rank * 1st Half	Minimum 2nd Half	Maximum 2nd Half	Avg 1st Half	Rank * 2nd Half	No. of Tested Locations
	Lbs/Day	Lbs/Day	Lbs/Day		Lbs/Day	Lbs/Day	Lbs/Day		1st Half / 2nd Half
CLINICAL:	0.011	0.013	**0.012**	**(5)**	0.023	0.026	**0.024**	**(2)**	29 / 26
INCINERATOR:	0.069	0.069	**0.069**	**(2)**	0.271	0.271	**0.271**	**(1)**	3 / 3
LAUNDRY:	0.533	0.536	**0.534**	**(1)**	0.008	0.010	**0.009**	**(4)**	6 / 5
OTHER:	0.027	0.030	**0.029**	**(4)**	0.002	0.006	**0.004**	**(5)**	12 / 11
RESEARCH:	0.028	0.031	**0.029**	**(3)**	0.013	0.016	**0.015**	**(3)**	58 / 69

* Rankings by loadings values

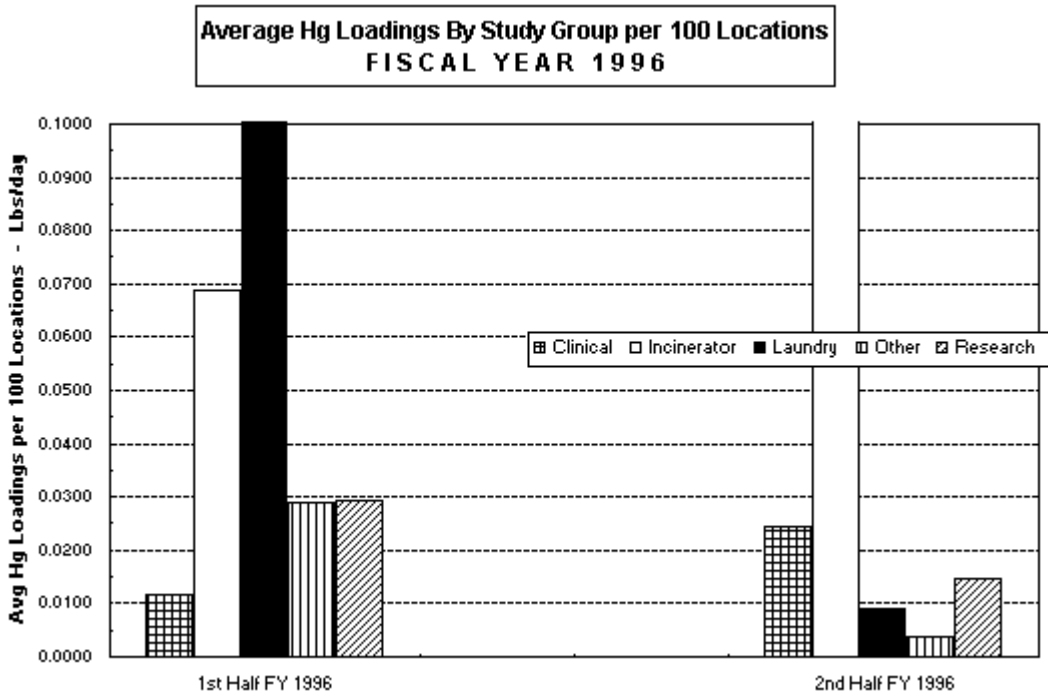

FIGURE 4

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8.0 PHASE I LOADINGS REVIEW (29 HOSPITALS)

One of our goals was to review the mercury loadings calculations performed in Phase I for 29 hospital facilities for Fiscal Year 1995 and to examine corresponding data for the following year to detect any loadings trends. While the Phase I study examined a total of 76 sampling locations within these facilities, discharge loadings were not calculated for locations that had no mercury concentration test data.[7] There were no mercury concentration data for 16 sampling locations in the first half-year of FY 1995 and for 29 locations in the second half-year.

For our review, we extracted the applicable loadings data for the same 76 sampling locations from the spreadsheets described above and created Table E-1 of Appendix E that presents the FY 1995 mercury loadings. Similarly, we created Table E-2 of Appendix E to present the corresponding FY 1996 mercury loadings. As in the Phase I study, we did not estimate discharge loadings from sampling locations without mercury concentration test data, *i.e.*, we included only "known" loadings. Refer to Table 8 for a summary comparison of the two studies.

As shown in Table 8, Phase I had estimated that the mercury discharge loadings from 29 hospital facilities contributed between 2.6 and 3.6 percent of total estimated MWRA system loadings during FY 1995. In contrast, our Phase II results suggest that the contribution was between 0.65 and 0.91 percent.

The difference in estimated discharge loadings for FY 1995 is primarily attributable to the detailed flow estimating procedure of our study that produced many lower than previously estimated facility discharge flows. In the Phase I study, for example, the sum of estimated facility discharge flows was 1.18 million gallons per day (MGD) in the first half of FY 1995. In this Phase II study, the corresponding total estimated flow was 0.35 MGD, a difference of about 70 percent. Besides the flow differences, we found a few unexplained differences in the mercury concentration data.

Our study also suggests that estimated FY 1996 mercury discharge loadings for the 29 Phase I hospital facilities were higher than those of FY 1995. From about 0.65 to 0.91 percent in FY 1995, our estimated FY 1996 mercury discharge loadings for the 29 hospitals ranged from about 1.8 to 2.5 percent of the estimated MWRA total system loading.

TABLE 8
ESTIMATED MERCURY DISCHARGE LOADINGS
FROM 29 SELECTED HOSPITALS
PHASE I STUDY (1995) VERSUS PHASE II STUDY

Period of Year	Phase I FY 1995 Loadings1 (Pounds/Day)	As % of Total System Load [2]	Phase II FY 1995 Loadings [3] (Pounds/Day)	As % of Total System Load [2]	Phase II FY 1996 Loadings [3] (Pounds/Day)	As % of Total System Load [2]
1ST HALF	0.040	5.2%	0.006 - 0.007	0.8 - 0.9 %	0.020 - 0.021	2.4 - 2.5 %
2ND HALF	0.029	3.8%	0.005 - 0.007	0.6 - 0.9 %	0.015 - 0.016	1.8 - 1.9 %

[1] Phase I Loadings were taken from tables entitled "Review of SMART Database, Q1 & Q2, Fiscal, 1995" and "Review of SMART Database, Q3 & Q4, Fiscal, 1995" in the End of Pipe Alternatives Subcommittee Final Report, June 1995.

[2] Estimated Total System Mercury Loading was 0.77 pounds/day for Fiscal Year 1995 and 0.83 pounds/day for Fiscal Year 1996 (from background data prepared for the MWRA Industrial Waste Report No. 12, October 1996).

[3] Refer to Appendix E, Tables E-1 and E-2, for Phase II loadings calculations for Fiscal Years 1995 and 1996, respectively.

Note: In the Phase I study, the sum of estimated facility discharge flows was 1.18 million gallons per day (MGD) from 60 sampling locations in the first half of FY 1995 and 0.82 MGD from 47 locations in the second half. In this Phase II study, the sum of estimated facility discharge flows was 0.35 MGD from 51 sampling locations and 0.38 MGD from 62 locations, respectively.

For FY 1996, first and second half-year loadings in Phase II were contributed by 65 and 61 sampling locations, respectively.

[7]Thus, the Phase I loadings estimates could be called the estimated "known" loading of the 29 hospital facilities.

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9.0 COMMENTS AND CONCLUSIONS

We believe we have fully met the goals of our Phase II task and have produced several mercury discharge loadings estimates for five groups of facilities with hospital-like sewer discharges. To aid in the evaluation of our study results, we have also provided several comparisons of our estimates with total industrial loadings and sewer system loadings. However, since the results of this study are based upon a limited amount of data, we advise appropriate caution in their use.

Although we are confident that our laboratory discharge flow model has produced good estimates of discharge flows on an overall basis, we are not as confident in our calculated mercury concentration averages for all sampling locations. We believe that additional testing at many existing sampling locations would lead to better estimates of average discharge mercury concentrations. Additional concentration data would also help individual facilities to better understand their mercury discharge position. On the other hand, since discharges having large flows usually had permit sampling requirements, 60 to 70 percent of our estimated total mercury loadings were contributed by locations having actual concentration data.

For sampling locations that had outliers in mercury concentration test data, we believe that causes of the outliers should be determined on a case-by-case basis so that any needed adjustments to the record can be made. In addition, we believe that the installation and calibration of wastewater flow meters at more sampling locations would lead to better discharge flow information than was available for this study.

Even with the necessary assumptions and approximations, we believe that this study provides important insights into the sewer discharge mercury loadings contributed by our five study groups. Specifically:

- During FY 1995 and FY 1996, our five study groups contributed roughly 50 percent of the known industrial mercury loadings while discharging only about 16 percent of the estimated total industrial discharge flow to the Boston Metropolitan Sewer Service Area.
- During this period, our five study groups contributed roughly 6 or 7 percent of total headworks mercury loadings while discharging only about 0.5 percent of the total treatment plant headworks flow.

- On a group basis, research facilities appeared to be the largest contributors of discharge mercury loadings. However, this result could have been expected since there were 193 research sampling locations out of 355 sampling locations examined in this study. Also, during one half-year period in FY 1996, laundry facilities were significant contributors of mercury loadings because of one laundry sampling location with a very high loading.
- On an individual basis, a typical incinerator facility had the greatest potential to be a large contributor of discharge mercury loadings followed by a typical research facility. Although a typical clinical facility had the potential of relatively high discharge mercury concentrations (see the *Group Concentration Averages* in Tables 1 and 2), its mercury loadings would be relatively low because of lower discharge flows.
- The Phase I End-of-Pipe Alternatives Subcommittee had estimated that the mercury discharges loadings from 29 selected hospital facilities represented between 2.6 and 3.6 percent of MWRA total system loadings during FY 1995. In contrast, our results suggest that the contribution from these facilities was between 0.6 and 0.9 percent for FY 1995 and between 1.8 and 2.5 percent in FY 1996.
- We also found that the total average mercury loadings discharged from the five study groups may have been between 0.02 and 0.08 pounds per day over the study period. Since this sum represents such a small quantity of mercury, one sporadic peak discharge had the potential to significantly affect the overall loadings for a particular day.[8] We observed such sporadic impacts in the discharge concentration data over the two-year

study period for sampling locations in several clinical laboratory, medical waste incinerator, hospital laundry, and research laboratory facilities. During FY 1995, for example, the data suggests that a research laboratory may have discharged 0.24 pounds of mercury in one day and, during FY 1996, a hospital laundry may have discharged 0.11 pounds of mercury in one day.

[8]Readers of this report are encouraged to refer to the Work Group's Mercury Management Plan Guidance Document for recommended guidelines to address mercury management issues including the control of psoradic high mercury discharges.

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APPENDIX A

Wastewater Flow Questionnaire and Tables of Wastewater Flow: Questionnaire and Data Calculations

NOTE: The following tables are all in MS Excel 4.0 worksheet format. They are not formatted in HTML, so in order to view them, you must download them to your machine. To do this in either Netscape or Internet Explorer, click your right mouse button on the link to the file you would like to see (on Macs, hold the mouse button down in the link), and a menu will pop up. Select "Save As" (or "Save Target As") and select the appropriate drive and folder on your machine to save to. You may then open the file in Excel.

WASTEWATER FLOW QUESTIONNAIRE AND TABLES OF WASTEWATER FLOW: QUESTIONNAIRE DATA AND CALCULATIONS

(Some browsers, such as later versions of Internet Explorer, will open the file directly in the browser window by clicking on the link with the left mouse button).

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APPENDIX F

NOTES OF MEETINGS
MERCURY MANAGEMENT SUBCOMMITTEE
FACILITIES LOADINGS SUBGROUP

FEBRUARY 22, 1996 TO DECEMBER 4, 1996

Notes from February 22, 1996

Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Karen Rondeau, MWRA & Bob Gingras, Earth Tech - Co-Chairs; Ed Cummings, Beth Israel Hospital; Peter Yarossi, MWRA

Notable Comments:

Bob Gingras presented the following slate of issues for discussion:

- The quality of data to be reviewed (number of data points, number of institutions)
- The extent of data to be reviewed (institutions versus industry, other)
- The accuracy of flow data (if estimated, how? if measured, confidence?)
- Focus group (28 institutions: more or less?)
- Questionnaire to focus group
- SMART data only or other, as well?
- Review periods (monthly, quarterly, semi-annual, fiscal years, calendar years)
- How will we deal with ND data points or MDLs above 0.2 ppb?
- Should we employ "Olympic Scoring" to discount the highs and lows (statistics)?

During the meeting, consensus was reached on the following points:

- Only SMART data will be used in the evaluation.
- A range of loadings will be calculated by factoring NDs and elevated MDLs as both zero as well as the numerical value of the MDL regardless of sensitivity (e.g., MDL of 0.2, 1.0 or 5 ppb).
- Review periods will be as follows: Prior to and inclusive of Fiscal 1994 (baseline), Q1&Q2 Fiscal 1995, Q3&Q4 Fiscal 1995, Q1&Q2 Fiscal 1996, Q3&Q4 Fiscal 1996 (ending June 31, 1996).

The following assignments were made for completion by the next meeting on March 7, 1996:

- A draft questionnaire for distribution to the focus group will be developed by Bob Gingras for discussion. The questionnaire will request information on methods of flow measurement/estimation, SMART sampling locations, etc.. The questionnaire will be reviewed and discussed during the next meeting with distribution (by the MWRA) intended prior to the third meeting on March 21, 1996.
- The names of institutions that will comprise the focus group will be compiled by Karen Rondeau. This list (which will likely be expanded well beyond the Phase 1 participant list) will be reviewed, augmented and/or culled during the next meeting.

The next meetings of the Loadings Subgroup were scheduled for 8:00 AM on March 7 and 21, 1996, respectively, at the offices of the MWRA.

Notes from March 7, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Karen Rondeau, MWRA & Bob Gingras, Earth Tech - Co-Chairs; Peter Yarossi, MWRA

Notable Comments/Actions:

- Minutes from the February 22, 1996 meeting were reviewed and approved for distribution.
- Bob Gingras presented a draft of the wastewater questionnaire that had been assigned at the previous meeting. After inputting changes discussed and approved during the meeting, the final questionnaire was prepared (copy attached). The questionnaire will be issued by the MWRA following development of the list of affected mercury dischargers (next item).
- Karen Rondeau presented a printout of all 1,500 currently permitted Industrial Sewer Users (inclusive of category 1 - 3) within the MWRA Services Area. Due to its extent, it was agreed that the MWRA would pare down the list to include only the following names which will become be known as the "Hospital List": Institutions, Hospitals, Universities, Biotech Facilities, Analytical Laboratories, and Clinics. This will be accomplished by doing a search of the current MWRA data base and sorting Users according to SIC code, name and data contained in files (to be reviewed by MWRA staffers). This "Hospital List" (which is expected to encompass 150 to 200 Users) will be reviewed, augmented and/or culled during the next meeting. It is intended that the questionnaire will be distributed by April 1, 1995 with responses expected on or before April 15, 1996 (two weeks is considered reasonable). The Subgroup agreed that the entire "Hospital List", once approved, will received the Wastewater Questionnaire. Depending upon the initial response, telephone calls may be made to encourage data submission.
- Due to the priority being placed upon the preceding, its was agreed that a presentation to the Subgroup on flow monitoring devices by Flow Tech would be delayed until May 2, 1996. Mr. Southwick will be asked to limit his presentation to no more than 1 hour. Karen agreed to relay the above information to Flow-Tech.

The meeting that was scheduled for March 21, 1996 was canceled and the start time for all future meetings was changed to 8:30 AM. The next meetings of the Loadings Subgroup at the offices of the MWRA were scheduled for March 28, April 18 and May 2, 1996, respectively.

Notes from March 28, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Karen Rondeau, MWRA & Bob Gingras, Earth Tech - Co-Chairs; Peter Yarossi, MWRA

Notable Comments/Actions:

- Final changes to the wastewater questionnaire were made in anticipation of Karen Rondeau being unavailable after April 12, 1996. The questionnaire will be issued by the MWRA not later than April 5, 1995 following finalization of the list of affected mercury dischargers (next item). MWRA will be responsible to attach a cover letter to the questionnaire to explain its purpose and the advantages to be derived by responding.
- Karen Rondeau and Peter Yarossi presented a pared down list of permitted industrial users including Institutions, Hospitals, Universities, Biotech Facilities, Analytical Laboratories, and Clinics which will now become known as the "Hospital List". The names on the Hospital List will be entered into a spreadsheet format so responses to the

questionnaire (above item) can be logged upon receipt. Responses will now be due on or before April 26, 1996.

- The presentation to the Subgroup on flow monitoring devices by Flow Tech will remain scheduled for May 2, 1996 and Bob Gingras is to confirm Mr. Southwick's participation during the prior week.. He will be asked to limit his presentation to no more than 1 hour.

Due to the above schedule change (item 2), the meeting that was scheduled for April 18, 1996 was canceled. The next meeting of the Loadings Subgroup at the offices of the MWRA was scheduled for 8:30 AM on May 2, 1996.

Mercury Management Subcommittee:
Loadings Subgroup
By:
Bob Gingras, Co-Chair

Notes from May 2, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Les Zenack, MWRA & Bob Gingras, Earth Tech - Co-Chairs; Peter Yarossi, MWRA
Notable Comments/Actions:

- Les Zenack volunteered to serve as the Loadings Subgroup Co-Chair until Karen Rondeau returns from maternity leave. His involvement will help to relieve some of Peter Yarossi's responsibilities who had been filling in as acting Co-Chair for the past month. The Subgroup welcomed Les' active participation.
- A presentation on types of flow meters, their applications, relative accuracy and selected regulatory implications was made by Mr. Ken Southwick of Flow-Tech, Inc..
- Peter Yarossi reported that, as of the time of the meeting, 91 responses out of the 232 questionnaires that had been issued on April 10, 1996 had been returned (nearly a 40% response rate) but had not yet been catalogued. Response information will now begin to be logged into the Subgroup's data base for analysis. Depending upon the Subgroup's initial review of the data, and after identifying those who have not yet submitted a response, an attempt to recontact selected sites to obtain their completed questionnaire will be discussed. Bob Gingras is to develop a spreadsheet format for use with the Subgroup's database which, while data is being encoded, will simultaneously calculate a basis for current hydraulic loadings from each point of discharge reported by the individual respondents. This spreadsheet is to be forwarded to Les Zenack on or before May 9, 1996 so he may subsequently incorporate it into the database before beginning data entry. Subsequent meetings will be used to augment, modify and manipulate data contained in the database to achieve the Subgroup's goals.

The next three meetings of the Loadings Subgroup were scheduled for 8:30 AM at the offices of the MWRA on May 30, June 13 and June 27, 1996, respectively.

Mercury Management Subcommittee:
Loadings Subgroup
By:
Bob Gingras, Co-Chair

Notes from May 30, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Les Zenack, MWRA & Bob Gingras, Earth Tech - Co-Chairs; Peter Yarossi & Chip Topjian, MWRA
Notable Comments/Actions:

- Les Zenack reported that approximately 140 of the 232 questionnaires that were originally issued had been returned. Of those that remain outstanding, Chip Topjian has

identified the facilities that reportedly discharge in excess of 1,000 gallons per day (MWRA database) and is calling facility points-of-contact to help elicit their response. It was agreed that this effort would likely continue until June 14, 1996 at which point the data gathering phase would be deemed closed and data manipulation would commence in earnest.

- Questionnaire Non-respondents will have whatever flow information is currently available from the MWRA internal database (including inspection reports) applied to their facilities. Questionnaire Respondents and/or Non-respondents without historical mercury monitoring results in the existing SMART database will have some form of "Qualified Respondent Group Average (QRGA)" applied to their discharge depending upon facility type. Some discussion ensued about culling outlyers (anomalous peaks and valleys) from the respondent database in developing the applicable QRGA but was left unresolved pending further debate at the next few meetings.
- It was agreed that the formula for estimating flows based on fixture count would be changed from subtracting to adding volumes contributed by NCCW sources, unsegregated sanitary sources and water treatment system for reasons explained in Bob Gingras' communication of May 15, 1996.
- It was agreed that the formula for estimating flows based on reactor sizing would be standardized around an 8 hour operational day.
- The formula for estimating flows based on fixture count may be modified as follows: for facilities having 50 fixtures or less, each fixture will rate at 10 gph; for facilities having between 50 and 100 fixtures, each fixture will rate at 7.5 gph; for those facilities having in excess of 100 fixtures, each fixture will rate at 5 gph. This will be further discussed at upcoming meetings.

The next two meetings of the Loadings Subgroup were scheduled for 8:30 AM at the offices of the MWRA on June 13 and June 27, 1996, respectively.

Mercury Management Subcommittee:
Loadings Subgroup
By:
Bob Gingras, Co-Chair

Notes from June 13, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Les Zenack, MWRA & Bob Gingras, Earth Tech - Co-Chairs; Peter Yarossi & Chip Topjian, MWRA

Notable Comments/Actions:

- Les Zenack reported that 142 of the 232 questionnaires that were originally issued had been returned. Chip Topjian indicated that he expects to receive 4 to 5 more replies by the stipulated cutoff date of June 14, 1996 so our final response percentage should be nearly 65%.
- Les Zenack then presented an analysis of flow estimates that had been calculated by fixture count versus those that had been reported by meter or facility estimate. He then explained certain anomalies and inconsistencies that would result as a function of variable flow allocation, e.g. rating fixtures at various gph values, unless the formulas being used were adjusted. Following his explanation, as is further embellished in communication dated June 3, 1996, it was agreed that the formula for estimating flows based on fixture count would be modified as follows: for facilities having 30 fixtures or less, each fixture will rate at 10 gph; for facilities having in excess of 30 fixtures, each fixture will rate at 5 gph.
- Finally, Les presented a limited printout of his current efforts at SMART mercury data manipulation as a function of review period (copies were not available for distribution as it is a work in progress). The current spread sheet sorts SMART mercury data according to respective Fiscal 1996 semi-annual review period {both Q_{1-2}, and Q_{3-4}) then calculates

the average mercury discharge concentration by facility discharge point allocating both 0 and the MDL to values reported below the MDL. The "average" concentrations produced on this spreadsheet will eventually by multiplied by the flow values being compiled on the flow database (discussed above) in order to calculate mass based mercury loading by facility to the MWRA sewerage system. Additional fields which will be used to identify discharge locations by type will be added to enable more detailed data sorts and to allow the computation of "Qualified Respondent Group Average (QRGA)" (refer to May 30, 1996 meeting minutes } for survey non-respondents.

- It was agreed that this calculation would be performed for the following 4 six month periods (according to MWRA Fiscal quarters):

Q_{1-2} , Fiscal 1995 July 1, 1994 thru December 31, 1995
Q_{3-4} , Fiscal 1995 January 1, 1995 thru June 30, 1995
Q_{1-2} , Fiscal 1996 July 1, 1995 thru December 31, 1995
Q_{3-4} , Fiscal 1996 January 1, 1996 thru June 30, 1996

Due to the amount of data encoding and spreadsheet construction now necessary, it was agreed that the meeting that had been scheduled for June 27, 1996 could be canceled. The next two meetings of the Loadings Subgroup were scheduled for 8:30 AM at the offices of the MWRA on July 31 and August 29, 1996, respectively.

Mercury Management Subcommittee:
Loadings Subgroup
By:_____
Bob Gingras, Co-Chair

Notes from July 31, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Les Zenack, MWRA & Bob Gingras, Earth Tech - Co-Chairs; Peter Yarossi, MWRA
Notable Comments/Actions:

An abbreviated meeting of the LSG was held on Wednesday, July 31, 1996 during which Les Zenack reported that manipulation of data, according to the parameters previously established, was proceeding according to schedule. To help facilitate data comparisons, Bob Gingras transmitted uncoded copies of the Phase 1 Hospital data base (Fiscal, 1994; and Q_1Q_2, Fiscal, 1995 & Q_3Q_4, Fiscal, 1995 to Les during the meeting.

The next meeting of the Loadings Subgroup was scheduled for 8:30 AM on August 29, 1996 at the offices of the MWRA.

Mercury Management Subcommittee:
Loadings Subgroup
By:
Bob Gingras, Co-Chair

Notes from August 29, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Les Zenack\Karen Rondeau, MWRA & Bob Gingras, Earth Tech - Co-Chairs; Peter Yarossi & Ana Echaniz MWRA
Notable Comments/Actions:

- Copies of data summaries for Fiscal, 1995 & 1996, in six month increments were reviewed. It appeared that certain "holes" were present in the tabulations which would need to be filled before the spreadsheets could yield final data for interpretation by the Subgroup. Specifically, Les was asked to fill in Qualified Group Respondent Averages (QGRA) and certain flow values before the Subgroup could view the documents as final. Les agreed to accomplish this task prior to the next meeting.
- Where efforts to fill flow "holes" fail, it was decided that they will be left indeterminate but listed along with reported mercury discharge values. The rationale employed here was that, perhaps, a reported discharge location had been disconnected during the review

period but after a data point had been generated. Without specific knowledge of a particular facility, it would be impossible to arbitrarily assign a flow value.

- In addition to the current breakdown of information, Les will identify the number of analytical data points used to calculate individual group averages. It was deemed unnecessary to provide this level of detail in the supporting spreadsheets but the total numbers should be reflected somewhere in our summary information.
- The Subgroup's Report will likely consist of a 4 to 5 page summary (inclusive of introduction\mission statement; assumptions and discussion) to be augmented by charts and graphs which will serve as a cover to four (4) Appendices: 1. flow database; 2. mercury concentration database; 3. data manipulation (mass balance calculations and grouping of facilities according to type); and, 4. meeting minutes. Bob Gingras agreed to prepare a draft of the introduction\assumptions section of the Report. Les was charged with finalizing the first 3 Appendices. Both components (if possible to be distributed ahead of time) will be discussed at the next meeting during which components of the findings and discussion section will be developed.

The next meeting of the Loadings Subgroup is scheduled for 8:30 AM on September 19, 1996 at the offices of the MWRA.
If changes to the above are required, please contact the undersigned.
Mercury Management Subcommittee:
Loadings Subgroup
By:
Bob Gingras, Co-Chair

Notes from September 19, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting
Attendees: Les Zenack\Karen Rondeau, MWRA & Bob Gingras, Earth Tech - Co-Chairs
Notable Comments/Actions:
Copies of the following completed documents were distributed by Les Zenack during the meeting:

- Fiscal 1995 & 1996 summaries (both tabular and graphical) of total mercury loadings to the MWRA Sewer System by the "Hospital List" according to subcategory (clinical, research, incinerator, laundry and other);
- "Qualified Respondent Group Averages" for Fiscal 1995 & 1996;
- "Data Manipulation" spreadsheet for Fiscal 1995 & 1996; and
- Abbreviated "Flow Database" for the "Hospital List" sorted according to subcategory.

The following documents remain to be provided by Les:

- Flow database;
- Mercury concentration database for Fiscal 1995 & 1996; and
- "Data Manipulation" spreadsheet for the 28 original Work Group members for Fiscal 1995 & 1996.

It was decided that the final versions of the above mentioned documents will have the names of the facility\institutions suppressed. This will allow their inclusion in the final Report while preserving the anonymity of the source of information.
A preliminary working draft of the Subgroup's final report was provided by Bob Gingras. Comments, additions and remaining sections will be discussed at the next meeting which was scheduled for 8:30 AM on November 7, 1996 at the offices of the MWRA.
If changes to the above are required, please contact the undersigned.
Mercury Management Subcommittee:
Loadings Subgroup
By:

Bob Gingras, Co-Chair

Notes from November 7, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Les Zenack\Karen Rondeau, MWRA & Bob Gingras, Earth Tech - Co-Chairs

Notable Comments/Actions:

An updated preliminary draft of the Subgroup's final report (dated November 4, 1996) was provided by Bob Gingras. Missing components of the document, as prepared and submitted by Les Zenack on September 26, 1996, were furnished by Les & Karen on disc and will be incorporated by Bob into the next version of the draft document. Once the final draft, inclusive of all appendices, is compiled, copies will be circulated to Les, Karen and Bob for final editing. Comments and additions to the document will be discussed at the next meeting which was scheduled for 8:30 AM on December 4, 1996 at the offices of the MWRA. Following that meeting, a final report will be prepared and released to the Mercury Management Subcommittee.

If changes to the above are required, please contact the undersigned.

Mercury Management Subcommittee:
Loadings Subgroup
By:
Bob Gingras, Co-Chair

Notes from December 4, 1996
Mercury Management Subcommittee: Loadings Subgroup Meeting

Attendees: Les Zenack\Karen Rondeau, MWRA & Bob Gingras, Earth Tech - Co-Chairs

Notable Comments/Actions:

Comments on the *Preliminary Draft Report* (dated November 11, 1996) were presented and discussed. Finally agreed upon language will be incorporated into the *Final Report* which is targeted for issuance on December 20, 1996 (see below). To help improve the readability of the final document, Les Zenack agreed to make selected formatting modifications to Appendix A, C and D (Fiscal, 1995) and provide Bob Gingras with original printouts (double sided) on or before December 9, 1996. Bob will concurrently check the document for typos and consistency of nomenclature.

Karen will check with Peter Yarossi and Joanne Grandchamp (Mercury Management Subcommittee Co-Chairs) and Kevin McManus, by December 13, 1996, as to whether it would be acceptable for the LSG to submit the final document to the Steering Committee at its next regularly scheduled meeting. If these parties see no reason not to, Bob will proceed to compile the document in final form for distribution to the Steering Committee on December 20, 1996. It was agreed that third party or peer review might occur once the Final Report is handed over to the Steering Committee.

If changes to the above are required, please contact the undersigned.

Mercury Management Subcommittee:
Loadings Subgroup
By:
Bob Gingras, Co-Chair

RETURN TO FACILITIES LOADINGS REPORT
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