Summary of “floatables” monitoring in Deer Island Treatment Plant effluent: 2006-2010

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SUMMARY OF FLOATABLES MONITORING IN DEER ISLAND TREATMENT PLANT EFFLUENT 2006-2010

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TABLE OF CONTENTS

1.0 INTRODUCTION 1
2.0 BACKGROUND 1
3.0 METHODS 2
3.1 EFFLUENT FLOATABLES 2
3.1.1 Sample Collection 2
3.1.2 Effluent floatables measurement 2
3.1.3 Other measurements 2
3.2 EFFLUENT FATS, OIL, AND GREASE, AND PETROLEUM HYDROCARBONS 2
3.2.1 Fats, Oil and Grease 2
3.2.2 Petroleum Hydrocarbons 3
3.3 DATA MANAGEMENT 3
4.0 RESULTS AND DISCUSSION 3
4.1 EFFLUENT FLOATABLES 3
4.1.1 Effluent floatables monitoring 2006-2010 4
4.1.2 Trends over time 4
4.2 EFFLUENT FATS, OIL, AND GREASE, AND PETROLEUM HYDROCARBONS 6
5.0 SUMMARY 9
6.0 CONCLUSIONS 10
7.0 REFERENCES 11

LIST OF TABLES

TABLE 1 1997 CONTINGENCY PLAN THRESHOLDS 1
TABLE 2 DESCRIPTIVE STATISTICS FOR DITP FLOATABLES MONITORING 2006-2010. 4
TABLE 3 MAJOR IMPROVEMENTS TO DITP FACILITIES AND PROCESSES 2000-2010 4
TABLE 4 DESCRIPTIVE STATISTICS FOR DITP EFFLUENT FATS, OIL, AND GREASE, AND FOR PETROLEUM HYDROCARBONS JANUARY 2006-DECEMBER 2010. 7
TABLE 5 WEEKLY AVERAGE DATA PER MONTH FOR DITP EFFLUENT FATS, OIL, AND GREASE, AND FOR PETROLEUM HYDROCARBONS. 7

LIST OF FIGURES

FIGURE 1 EFFLUENT FLOATABLES SAMPLING DEVICE 2
FIGURE 2 PERCENTILE BOX PLOTS OF EFFLUENT FLOATABLES CONCENTRATIONS 2003-2010. 5
FIGURE 3 AVERAGE EFFLUENT FLOW AND CONCENTRATION OF FLOATABLES IN DEER ISLAND EFFLUENT BY (NOMINAL) MONTH, 2006-2010. 5
FIGURE 4 REGRESSIONS OF EFFLUENT FLOATABLES CONCENTRATIONS ON EFFLUENT FLOW. 6

1.0 Introduction

Marine debris has been an ongoing issue in the Gulf of Maine (Hoagland and Kite-Powell 1997). An early environmental concern related to the Massachusetts Water Resources Authority (MWRA)'s use of an effluent outfall to discharge to Massachusetts Bay was that the aesthetics of the marine environment would be protected, and that the discharge would not contain sewage-related "floatable" material that could be an aesthetic nuisance or harm marine life. MWRA has monitored floatables in the effluent from Deer Island Treatment Plant (DITP) since 2002, and in the waters of Massachusetts Bay since 2000. The DITP effluent floatables sampling program ended in December 2010; effluent sampling for fats oil and grease (FOG) and petroleum hydrocarbons (PHC) continues. This report follows on a previous report (Rex *et al.* 2008) and presents the results of MWRA's floatables, FOG, and PHC monitoring of treated effluent for 2006-2010.

2.0 Background

Early in the planning of the effluent outfall monitoring program, before DITP was built, two Contingency Plan thresholds aiming to measure effluent floatables were developed, shown in Table 1 (MWRA 1997 November).

Table 1. 1997 Contingency Plan thresholds

PARAMETER TYPE/LOCATION	PARAMETER	CAUTION LEVEL	WARNING LEVEL
Effluent	Floatables	None	5 gallons/day in final collections device
	Oil and grease (PHC)	None	15 mg/L weekly (15,000ug/L)

However, when DITP began to come online in the late 1990s, it became clear that it was not logistically feasible to measure floatables in the "final collection devices"—inaccessible tip tubes in the disinfection basins. Furthermore, the threshold was based on floatables captured rather than floatables in the discharge. In 2000, MWRA requested Outfall Monitoring Science Advisory Panel and regulatory review of the floatables Contingency Plan threshold. As a result of this review, revised floatables requirements were included in the first revision of the Contingency Plan (MWRA 2001). The revised plan deleted the trigger parameters and thresholds for floatables, but required MWRA to "make regular observations of wastewater during treatment to determine whether floatables are removed as expected and whether oil and grease discharges are within the limits established by the NPDES permit." MWRA developed a sampling device to measure floatables in the final effluent at DITP. In addition, MWRA monitors FOG and PHC in the final effluent. In 2010, (MWRA 2010) regulatory agencies agreed that enough effluent floatables data had been collected and agreed with MWRA to end the floatables sampling program at DITP.

In addition to effluent sampling, MWRA incorporated sampling for floatables at the outfall site in Massachusetts Bay, using a net, during nearfield water column monitoring surveys. This sampling began in 2000 before the outfall came online, and includes an area directly over the outfall as well as a reference site northwest of the outfall. In 2010, the sampling plan for monitoring ambient floatables in Massachusetts Bay was modified to focus on wet weather sampling (MWRA 2010). Those results will be in a future report.

3.0 Methods

3.1 Effluent Floatables

The requirement to monitor publicly owned treatment works (POTW) effluent floatables is unusual; there is no EPA-approved standardized method for sampling, characterizing and quantifying this parameter. Therefore, MWRA developed its own procedures and carried out a pilot study in 2002 to verify that the measurements were consistent and reproducible.

3.1.1 Sample Collection

MWRA staff designed an innovative sampling system (Figure 1). See Rex *et al.* (2008) for a detailed description. Samples were collected at the end of the west disinfection basin, after the final tip tube and scum baffle, prior to discharge to the outfall. Sampling was flow-paced; a pump collected from the sample lines, and the effluent passed through a rotary drum screen to a hopper. The sample collection system operated almost continuously, with the hopper being emptied and the floatables measured approximately every two weeks.

Figure 1. Effluent floatables sampling device

3.1.2 Effluent floatables measurement

See Rex *et al*. (2008) for detailed descriptions of floatables measurement methods. The sample was placed in a graduated strainer container, compressed, and volume estimated to the nearest 50 mL. [1]After the volume was measured, the sample was dried and weighed to the nearest 0.1 g. Floatables quantities are standardized to plant flow and sampling time, and reported as parts per billion effluent.

3.1.3 Other measurements

Related parameters measured include plant flow and flow through the sampling device.

3.2 Effluent Fats, Oil, and Grease, and Petroleum Hydrocarbons

3.2.1 Fats, Oil and Grease

[1] The compression step does not eliminate all air, but does to provide an estimate of volume as a surrogate for the "original" floatables threshold. Weight is a much more consistent measure of the amount of material present.

Fats, oil, and grease (FOG) is measured as the hexane extractable fraction by EPA Method 1664 Revision A. A detailed description of the method is in Rex *et al.* (2008). In brief, extractable materials that may be determined are relatively nonvolatile hydrocarbons (i.e. vegetable oils, animal fats, waxes, soaps, greases) and related materials. A 500-mL grab sample is collected weekly from the final effluent; samples are filtered through an activated C18 disk that is selective for fats oils and greases. The disk is air dried and eluted, evaporated and weighed. Depending on which laboratory analyzed the samples, the reporting limit varied.

3.2.2 Petroleum Hydrocarbons

Details of the measurements of petroleum hydrocarbons (PHC) are given in Rex *et al* (2008). PHC are measured as extractable petroleum hydrocarbons (EPH) using the Massachusetts Department of Environmental Protection Method for the Determination of Extractable Petroleum Hydrocarbons, (MADEP-EPH-04 Revision 1.1 May 2004).

3.3 Data Management

Data management, quality assurance, audit, and corrective action procedures are documented in the MWRA Department of Laboratory Services (DLS) Quality Assurance Management Plan (QAMP), and will not be repeated in detail here. Field measurements and laboratory analytical results are entered into the DLS Laboratory Information Management System (LIMS). After data have been validated and approved by the DLS, Deer Island Process Monitoring staff exports the records from LIMS for inclusion into the Deer Island Treatment Plant Operations Management System (DITP OMS) Oracle database. Section 7.0 of the QAMP documents data validation and reporting procedures. DLS' audit procedures are documented in Section 9.0 and corrective action procedures are documented in Section 11.0 of the QAMP. In addition, the Program Manager, Process Engineering reviews all data for technical reasonableness.

The Review, Validation, and Approval processes described in the QAMP are employed to ensure conformity with DLS and with client data quality requirements. Reported results must be traceable, i.e., verifiable by review of its associated documentation. All laboratory results for a given sample must be traceable throughout the entire analytical process applied to the sample. Traceability is maintained through LIMS (which stores all of the pertinent data associated with the sample) and by the utilization of various logbooks (preparation, analytical, and instrumental), instrument raw data printouts, electronic files, and spreadsheets. If the data are not consistent with the QC objectives specified in the QAMP reviewers mark the data as invalid and it is excluded from or flagged as invalid in the DITP OMS database.

DITP process control staff measured the floatables directly and entered the data directly into a computer spreadsheet.

4.0 Results and Discussion

4.1 Effluent Floatables

This section presents the effluent floatables results for the last five years of monitoring: 2006-2010. Details of the characterization of the floatables are in Rex *et al*. (2008).

4.1.1 Effluent floatables monitoring 2006-2010

The data described in this section were collected from January 2006 through the end of December 2010. Ninety-three samples were collected, during all types of weather and all levels of flow. The average sampling period was 18.1 days. The amount of non-degradable floatables is estimated as 14% of the mean floatables weight (Rex *et al*. 2008), and averaged 4.4 ppb overall.

Table 2 Descriptive statistics for DITP floatables monitoring 2006-2010.

YEAR	N SAMPLES	MEAN DAYS/SAMPLE	MEAN FLOW DURING SAMPLING (MGD)	MEAN FLOATABLES VOLUME (PPB)	FLOATABLES WEIGHT (PPB)	
					MEAN	EST. NON-DEGRADABLE (PPB)
2006	16	19.6	399	112	30	4
2007	18	18.0	345	112	30	4
2008	18	20.6	401	113	31	4
2009	22	15.5	360	130	33	5
2010	19	17.8	400	138	33	5
Total	93	18.1	380	122	32	4.4

4.1.2 Trends over time

Improvements and upgrades to the facilities and treatment processes were made over the past 10 years (Table 3). In addition, as a result of improvements in the secondary treatment process which began in early 2005, MWRA was able to increase the amount of flow through secondary treatment, and thus the secondary clarifiers, which resulted in a substantial decrease in floatables discharged (Rex *et al*. 2008). Inter-annual patterns of the amounts of floatables are shown as percentile box plots in Figure 2. Overall, amounts are lower in 2006 through 2010 than for 2003-2005. Both the variability and the amount of floatables discharged from the final effluent have remained substantially lower since 2005. Figure 3 shows treatment plant flow and effluent floatables averaged by month over the past five years: 2006-2010.

Table 3. Major improvements to DITP facilities and processes 2000-2010

DATE	IMPROVEMENT
September 6, 2000	New outfall diffuser system online
March, 2001	Upgrade from primary to secondary treatment completed
October, 2004	Upgrades to secondary facilities (clarifiers, oxygen generation)
April 2005	Sludge/filtrate line between Deer Island and Fore River operational
2005-2009	Improved removal of TSS etc due to more stable process
2010	Major repairs and upgrades to primary and secondary clarifiers

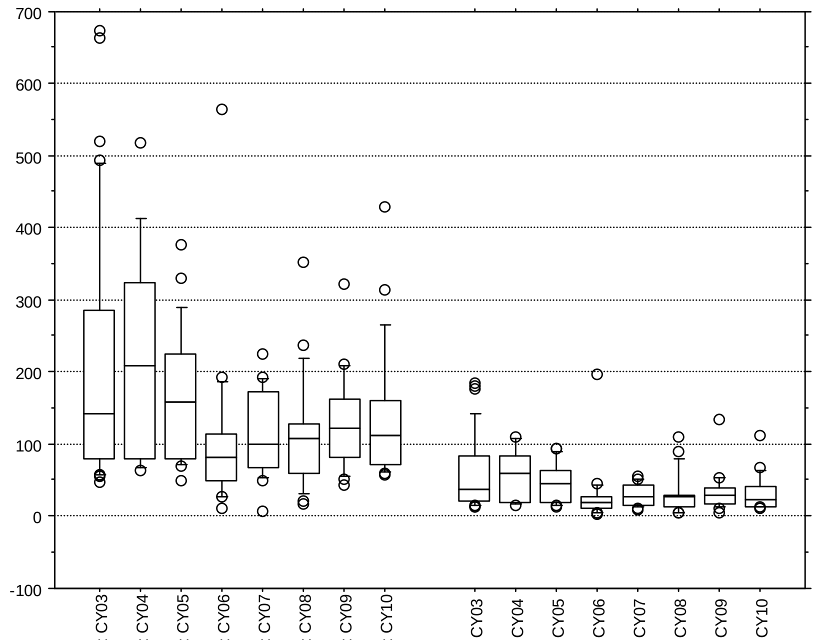

Figure 2 Percentile box plots of effluent floatables concentrations 2003-2010.

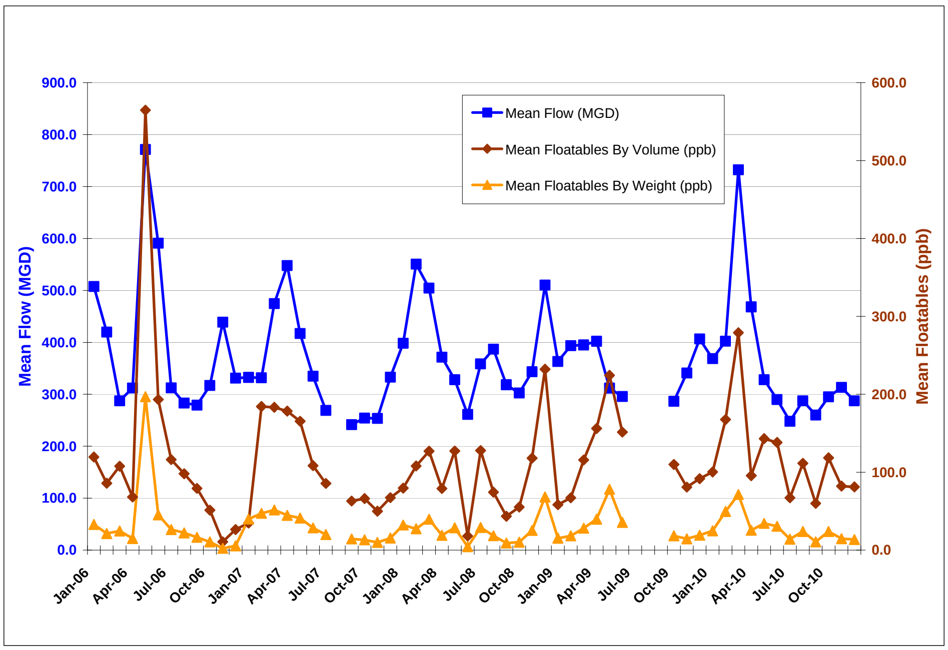

Figure 3 Average effluent flow and concentration of floatables in Deer Island effluent by (nominal) month, 2006-2010.

The multi-day sampling periods often extended beyond the first and last days of a given month, therefore the aggregations by month are approximate. Data gaps were usually caused by mechanical failures or maintenance of the automated sampler, or maintenance of the disinfection basin.

Overall, the trends for amounts of effluent floatables parallel treatment plant flow, with less during low-flow periods and increased amounts during higher flows. It is likely that periods of high flow, which are due to wet weather, bring more floatable material (street refuse, etc.) into the treatment plant. Also during periods of high flow, removal efficiency may be somewhat less.

Regression analyses of floatables by volume and weight on flow are shown in Figure 4. Flow explains 47% of the variance in floatables volume and 41% of the variance in weight, and both regressions are highly significant ($p < 0.0001$).

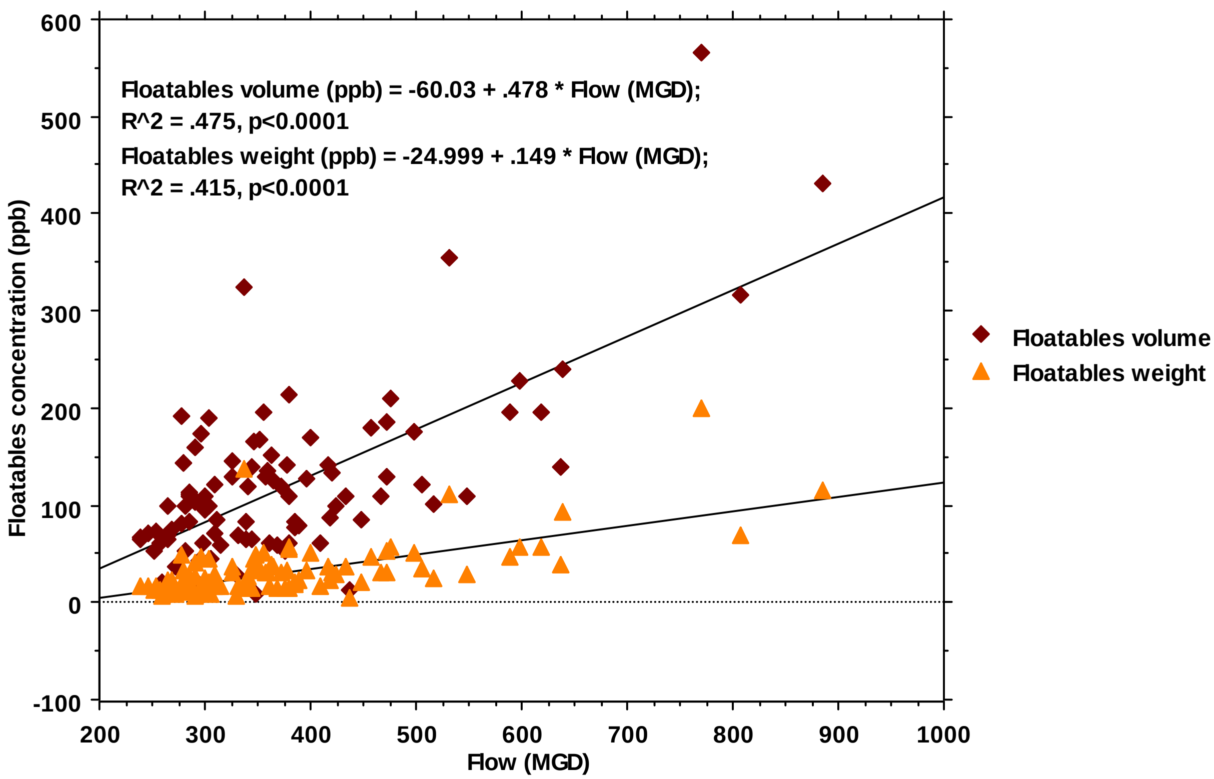

Figure 4 Regressions of effluent floatables concentrations on effluent flow.

4.2 Effluent Fats, Oil, and Grease, and Petroleum Hydrocarbons

From January 2006 through December 2010, 322 effluent samples were tested for total fats, oil, and grease (FOG) and 313 samples for petroleum hydrocarbons (PHC). For FOG, all but 29 samples had levels below the detection limit. For PHC, 291of 313 samples were non-detects. Table 4 summarizes the monitoring data. Table 5 lists the monthly average data from January 2006 through January 2010. For months in which all the samples were below detection limit (indicated by a "<" sign), the value presented in Table 5 is the highest detection limit used during the month. For months in which the constituent was detected in one or more samples, the numerical values are averaged (i.e. the non-detects are not considered). Thus, the weekly average is a conservative value. FOG, which includes non-petroleum fat, had a peak weekly average of 10.2 mg/L. The Contingency Plan threshold for petroleum oil and grease is a weekly average of 15 mg/L or 15,000 ug/L. Based on monthly data, the highest weekly average for PHC over these five years was 900 ug/L, far below the threshold.

Table 4 Descriptive statistics for DITP effluent fats, oil, and grease, and for petroleum hydrocarbons January 2006-December 2010.

	Fats, Oil, and Grease (Mg/L)	Petroleum Hydrocarbons Threshold = 15,000 ug/L
Number of samples	322	313
Non-detects	293	291
Minimum detected	1.2	200
Maximum	19	910
Lower Detection Limit Range	1.2-8.54	100-500

Table 5 Weekly average data per month for DITP effluent fats, oil, and grease, and for petroleum hydrocarbons.

	Fats Oil and Grease (Mg/L) Maximum weekly average by month	Petroleum Hydrocarbons (ug/L) Maximum weekly average by month
Jan-06	< 7.0	< 220
Feb-06	< 7.0	706
Mar-06	< 7.0	< 200
Apr-06	< 7.0	271
May-06	< 7.0	227
Jun-06	< 7.0	< 210
Jul-06	< 7.0	240
Aug-06	< 7.0	< 210
Sep-06	< 7.0	< 230
Oct-06	< 7.0	< 200
Nov-06	< 7.0	246
Dec-06	< 7.0	< 200
Jan-07	< 7.0	< 200
Feb-07	< 7.0	< 200
Mar-07	< 7.0	< 230
Apr-07	< 7.0	< 230
May-07	< 7.0	< 200
Jun-07	< 7.0	< 220
Jul-07	< 5.0	< 240
Aug-07	< 5.0	820
Sep-07	< 5.0	350
Oct-07	< 5.0	440
Nov-07	< 5.0	445
Dec-07	7.9	410
Jan-08	< 5.0	270
Feb-08	< 5.0	< 250
Mar-08	< 5.0	< 220
Apr-08	< 5.0	< 220

	Fats Oil and Grease (Mg/L) Maximum weekly average by month		Petroleum Hydrocarbons (ug/L) Maximum weekly average by month	
May-08	<	5.0	<	210
Jun-08		5.7	<	220
Jul-08		6.4	<	400
Aug-08		10.2	<	200
Sep-08		3.1	<	400
Oct-08		2.8	<	500
Nov-08		3.0	<	400
Dec-08	<	7.0	<	400
Jan-09	<	7.1	<	400
Feb-09	<	8.1	<	500
Mar-09	<	7.1	<	500
Apr-09	<	6.7	<	400
May-09	<	7.0		900
Jun-09	<	6.7	<	200
Jul-09	<	6.9	<	200
Aug-09	<	8.0	<	200
Sep-09	<	7.0	<	400
Oct-09	<	6.9	<	200
Nov-09	<	7.3	<	200
Dec-09	<	7.6	<	200
Jan-10	<	7.3	<	200
Feb-10	<	7.4	<	200
Mar-10	<	7.1	<	200
Apr-10	<	7.0	<	200
May-10	<	7.4		500
Jun-10	<	7.8		400
Jul-10	<	7.1	<	200
Aug-10	<	8.5	<	200
Sep-10	<	6.7	<	200
Oct-10	<	6.9	<	200
Nov-10	<	7.1	<	200
Dec-10	<	7.1	<	200

5.0 Summary

MWRA used a flow-paced, quantitative method for sampling floatables in DITP effluent which was sensitive and reproducible. Previous analyses showed the total dry weight of floatables is a good estimator for the amount of both degradable and non-degradable materials in the samples; total floatables are composed of about 86% degradable and 14 % non-degradable material (Rex *et al.* 2008). Floatable materials in final effluent are measured at the parts per billion level: over the past five years the mean volume was 122 ppb, a decrease from the previously reported 168 ppb, and mean weight was 32 ppb, a decrease from the previously reported 45 ppb. On average, non-degradable materials were present at an estimated 4.4 ppb by weight, a decrease from the previously reported 6 ppb. Previous analyses (Rex *et al.* 2008) showed that floatables weight and floatables volume are highly correlated; weight is a stable measure of quantity, and less subject to measurement error than volume. In the effluent sampler floatables of most concern—plastic bags—are rare; condoms and tampon applicators are sometimes found. Most of the non-degradable material was in small pieces. For example, fruit labels and cellophane-type wrappers were consistently present in the sampler. Much of the degradable material is bits of fat and plant matter.

The amount of floatable material increases with increasing flow rates through the plant, which may result from both increased matter in influent (street runoff) and reduced removal efficiency at higher flow rates. However, even at the highest flows, material was present at only <200 ppb by weight. Data collected over the past five years confirm that quantities of effluent floatables at DITP have decreased, likely a result of physical improvements to the secondary treatment facilities, including improved tip tubes, and improvements to the biological process.

For fats, oil and grease (FOG) the overall mean was 3.46 mg/L (assuming ½ the detection limit for non-detects) and the maximum weekly mean was 10.22 mg/L. For petroleum hydrocarbons (PHC), the mean value was 134 ug/L (assuming ½ the detection limit for non-detects) and the maximum weekly mean was 100 ug/L. These values are well below the Contingency Plan threshold of 15,000 ug/L weekly average.

These data show that floatable debris (both degradable and non-degradable), FOG, and PHC are found at very low levels in DITP effluent. In particular, materials of concern such as petroleum grease and plastics that are aesthetically offensive or could harm wildlife are rare in the effluent.

6.0 Conclusions

Eight years of effluent monitoring (2003-2010), after the initial pilot period in 2002. showed only very low levels of floatables, measured in the parts per billion range, in final effluent at DITP, and levels of fats oil and grease and petroleum hydrocarbons are extremely low. In addition, ten years of field observations and net tows since the outfall came online have found no petroleum grease and no sewage-derived plastics in the waters at the outfall site. The last five years showed less material than the first three years. We conclude that the outfall is not a source of floatables of concern to the marine environment either aesthetically or to marine life. In 2010, state and federal regulatory agencies agreed with MWRA’s request to end the effluent floatables sampling study. The ambient floatables sampling study at the outfall discharge site in Massachusetts Bay will continue for a minimum of another two years (2011 and 2012) with the objective of sampling after wet-weather related treatment plant blending events. The results of the ambient sampling will be presented in a future report.

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