

ARCADIS BBL

Appendix A

Field Notes and Photographs

10/30/06

0800

Meet w/ Ian Ippolito (ITI)
at EXHIBIT.

0910 BMJ on site.

BT, ITI marked locations
along both banks from
downstream to upstream.

BMJ surveyed locations
Started at FRT 12, FRT 7,
FRT 8, FRT 9.

1230 BMJ, BT, & ITI looked
to upper stretch to survey
points. BMJ cbl to survey
points FRT 4 thru FRT 12
from land.

RESUME:

Brian Laminis - BBL

Ian Ippolito - EXHIBIT

Matt Lupo - BMJ

10.30.06

Outfall Observation

Location	Shore	Dia	Construction
1	A	36	concrete
2	B	12	steel
3	B	16	corrugated steel
4	B	16	steel
5	A		put make up city of Fort WVTP
6	A		water make up city of Fort WVTP
7	A	24	"
8	A	24	concrete w bars
9	A	24	concrete w rip rap
10	B	24	concrete
11	A	36	concrete
12	A	12	concrete - pipe full of debris
13	A	12	PVC corrugated
14	B	36	concrete set back in inlet
15	B	10	steel
16	B	36	corrugated steel
17	B	24	steel

10.31.06

0700 BBL & EXPONENT @ SITE

PREP BOAT, DISCUSS HOSPITAL

ROUTE. PERSONNEL ON SITE

B. COOMIS - BBL

R. KUHN - BBL

I. IAPOLITO - EXPONENT

0800 Launch boat for FRT-9

Measurements from left bank
facing upstream

0900 Set up @ FRT-8

Health: Safety topic: back safety,
'jackets' required @ all times
on boat

1015 K. Blizzard @ launch area

1030 Set up @ FRT-7. K. Blizzard
requested we hold off as governor
7th expected to be @ Farmers' Market

10-31-06

FRT 9

WIDTH: 188
Locations: 47, 9A, 141

0-141 [FRT-9C]
No sediment grab.
Rock Bottom
Time: 0800
water 14.0
PID —

0-191 [FRT-9B]
Brown fine sand, to organics
A med to coarse sand, leaf
twigs, to fine gravel
Time: 0810
PID: 0.0
water 10.7

Probing Tube: 3.3
Sand
Time: 0830

0-47 [FRT 9A]
Brown fine sand, to silt, leaf
organics, root mass
Probing tube: 6.6
Time: 0830
PID: 0.0
water: 3.6

[FRT DUP 1]

FRT-8

10.31.06

River width: 199

Stations: 485, 97, 145.5

145.5 [FRT B-C] Time: 0900
water depth: 9.6
PID: 0.0

Brown fine sand, to med to
course sand, to fine gravel
to organics (leaves)
Probe: 4.4

0497 [FRT B-B] Time: 0910
water depth: 10.0
PID 0.0

Grey brown fine to coarse sand, little
fine to medium gravel, to silt, to
organics (twigs, shells, wood), to slog
Probe: 2.8

0485.5 [FRT B-A] Time: 0920
water depth: 12.7
PID: 0.0

Grey brown fine to med gravel, to
fine sand, to silt, to coarse
(shells, leaves)
Probe: 0.3

10.3106

FRT-7

River width: 252

Stations: 63, 126, 189

Time: 1210
water depth: 2.1

FRT-7C

1089

TID: 00

~~Medium~~ Gray brown
silty fine sand
to organic (leaves, twigs)

Probing Tube: 8.9

MS/PMSD

FRT-7B

1126

Time: 1220 TID: 00

Water Depth: 70

No recovery of sediment

all taken mussels

Probing Tube: 3.2

FRT-7A

0163

Time: 1230 TID: 00

Water Depth: 11.0

Gray brown fine to med sand, to
coarse sand, to silt, to organic (shells
leaves)

Probing Tube: 0.1

10.31.06

LOWER REACH
SAMPLES

Core collected from FICT 7C

Penetrate - 4.6

Recovery: 3.9

Hydrocarbon like odor present w/core

10.31.06

FRT-12

RIVER WIDTH: 180
STATIONS: 46, 92, 138

FRT-12C

1438

TIME: 1330 PM: 0.0

WATER DEPTH: 8.0

Brown very loose silt, little organic (leaves) to very fine sand

Probing Info: 5.0

FRT-12B

0492

TIME: 1337 PM: 0.0

WATER DEPTH: 10.1

Gray brown fine sand, to med to coarse sand, to organic (wood Zebra mussels) to fine gravel

Probing Info: 2.2

FRT-12A

0446

TIME: 1340 PM: 0.0

WATER DEPTH: 10.0

Med to coarse sand, to organic (Zebra mussels)

Probing Info: 0.2

10.31.06

FRT-6
River Widen: 167
Stations: 42, 84, 126

FRT 6-C

1426
Time: 1420 Pini 0.0
Water Depth: 8.0
Grey brown silt, very fine sand,
to organic (leaves, zebra mussels)
to shorn
PROBIO INFO: 2.5

0184 FRT 6-B

1430
Time: 1435 Pini 0.0
Water Depth: 9.7
Grey brown silt to mud sand, little
course sand, to fine to med gravel,
to silt, to organic (zebra mussels)
PROBIO INFO: 2.0

FRT 6-A

0142
Time: 1435
Water: 11.0
No sediment recovered.
All Rock/Grave
PROBIO INFO: 0.0

10.31.06

FRT-5

River WIDEN: 159

STATIONS: 40, 80, 120

1455

FRT-5C

TIME: 1555

RD: -

WATER DEPTH: 9.0

1420

No sample recovered, all
rock of tr zebra mussels
Problem info: 0.0

FRT-5B

TIME: 1503

RD: 0.0

water depth: 9.5

Gray brown fine sand, tr mud to coarse
sand, tr silt, tr organic (leaves,
zebra mussels)

Problem Info: 1.5

WATER: 8.4

FRT-5A

TIME: 1503

RD: 0.0

Gray brown fine to med sand,
tr coarse sand, tr silt, tr organics
(zebra mussels, shells)
Problem Info: 2.6

10.31.06
Actually FRT 10

FRT-10

River width: 185

STATIONS: 46, 92, 138

T.

FRT-10A

Time: 1555 P: 0.0

0446

WATER DEPTH: 7.9

DK grey brown fine sand,
little silt, dr organics (twigs,
Zebra mussels), stems, slight
odor

Probing Into: 3.3

Time: 1555 P: 0.0

0492 FRT-10B

Water Depth: 9.7

Grey brown fine to med sand, fr
course sand, dr silt, fr organic
(shells)

Probing Into: 2.1

1438 FRT-10C

Time: 1550 P: 0.0

water depth: 8.7

Grey brown fine to med sand, little
course sand, to fine gravel, fr organic
(twigs, zebra mussels) fr silt

Probing Into: 1.3

10.31.00

FRT-7C

Recovered: 3.9

Pen: 5.8

Probe: 8.9

0.0.2 Sampled w/ surficial

0.2-12 - Dk grey Brown loose
AD 00 silt, to fine sand, to
organics (rootlets) strong odor
FRT Dup 2, FRT-7C
2-12

12-24 - Dk grey Brown loose
AD 00 silt, to fine sand, to organics
(rootlets) strong odor
FRT 7C 12-24

AD 0.0
24-36 - Dk grey brown sandy
clearing w/ depth
FRT 7C 24-36

AD 0.0
36-46 - Dk grey brown sand, little
silt, trace odor
FRT 7C 36-46

11.1.06

FRT-10

Rud. Width: 1417
Stations: 39, 78, 117

0+39

FRT-10A

0750 TIME: 9.8 PD: 0.0
WATER DEPTH: 9.0

Gray brown ^{or} loose silt, to fine
Sand to organics (leaves, twigs), sl. shag
Pebbles info: 3.5
FRT Dur 3

0+78

FRT-10B

TIME: 0800 PD: 0.0
water depth: 10.0

Gray brown fine med sand, to silt,
to organics (leaves twigs) slight stream
Pebbling info: 2.5

1+117

FRT-10C

TIME: 0815 PD: 0.0

water depth: 11.0
Gray brown fine to med sand, little
course sand to fine gravel,
to organics (zebra mussels, wood)
Pebbling info: 1.0

11-1-06

FRT-11

River Width: 152

Stations: 38, 76, 114

FRT-11A

Time: 0855 PM: 00

Water depth: 9.2

No Sediment

Probing Inco: 0.0

FRT-11B

Time: 0900 PM: 00

Water depth: 11.5

Dk grey brown fine to med sand
to coarse sand, to silt, to fine
gravel, shaly present, slight odor
probing inco: 1.3

FRT-DUG 3

FRT-11C

Time: 0905 PM: 00

Water depth: 9.0

Grey brown fine to med sand
to silt, to organics (leaves, zebra
mussels) slight shear.

Probing Inco: 3.6

11.1.06

FRT 4

River width: 155

Stations: 99, 76, 117

1 + 17 FRT-4C

TIME: 0855 PID:

WATER DEPTH: 10.7

Brown very loose silt, to fine sand,
to organic (zebra mussels, leaves)
Probing Info: 0.2

0178 FRT-4B

TIME: 0940 PID: 03

water: 10

Dk grey brown fine to med sand
to coarse sand, to fine gravel,
to silt, to organic (zebra mussels, wood)
Probing Info: 2.0

0139 FRT-4A

TIME: 0945 PID: 00

water: 8.6

Brown silty fine sand, to med coarse
sand, to fine gravel, to organic
(zebra mussels, leaves)
Probing Info: 3.0

FACILITY REACH CORE COLLECTED

FRT-4A

Pen 3.0

REC 2.6

11/10/06

FRET-3

River width: 150

Stations: 37.5, 75, 112.5

112.5 FRET-3C Time: 1030 PD: 0.0
water depth: 10.0

No sediment at zebra mussel
Probing info: 0.8

0475 FRET-3B Time: 1035 PD: 0.0
water depth: 8.0

Grey brown fine to med sand, to coarse
sand, to silt, to fine gravel, to
zebra mussels

Probe info: 1.2

0437.5 FRET-31A Time: 1040 PD: 0.0
water: 6.6

Grey brown fine to med sand, to silt
to organics (leaves)
Probing info: 3.1

11-1-06

FR T-2

RIVER WIDTH: 129

STATIONS: 32, 64, 96

0+32 [FR T-2A] TIME: 1115 PP: —

WATER DEPTH: 11.0

No sediment, zebra mussels

Probing Info: 1.5

0+64 [FR T-2B] TIME: 1120 PP: 0.0

water depth: 11.2

Gray brown fine to med sand, to coarse sand, to fine gravel, to silt, to organic (leaves, zebra mussels)

Probing Info: 1.3

0+96 [FR T-2C] TIME: 1130 PP: 0.0

water depth: 6.5

Brown w/ base silt, little leaves, to fine to coarse sand

Probing Info: 7.5

11/106

FRT-1

River Width: 115
Stations: 29, 58, 87

0+87 FRT-1C TIME: 1200 PID: 0.0

Water Depth: 6.5
Brown fine med sand, little leaves
to coarse sand, to silt, to zebra
mussels
Packing Info: 2.4

0+58 FRT-1B TIME: 1205 PID: 0.0

Water depth 12.8
Brown fine to medium gravel
little brown med sand
Not enough sediment for a sample
Packing Info: 0.1

0+29 FRT-1A TIME: 1210 PID:

Water depth: 9.2
No sample - all zebra mussels
recovered
Packing Info: 1.3 - all zebra mussels

11.1.06
Time: 1300

FRT-12C

1"-12" DK grey brown very loose silt
+ fine sand, light odor,
to shear

RD: 0.0

FRT-12C (2-12)

12"-24"

DK grey brown fine to med sand
to silt, to organic (leaves, twigs)
FRT-12C (12-24)

RD: 0.0

24"-36"

SAA 34-36" SILTY LEAFS w/
FRT-12C (24-36) strong odor.

RD: 0.0

~~SA~~

Probe: 5
Pen: 4
Rec: 3

11.1.06

FRT 4A

Dike - 3

Per - 3

Rec - 2.5

2-12 - Dk grey brown fine to coarse sand, to fine gravel to wood
PID 0.0

12-24 - Grey brown - fine to med sand to coarse sand to wood
PID 0.0

24-30 Grey brown fine sand to med to coarse sand, to wood
PID 0.0

FRT 4A (2-12)

FRT 4A (12-24)

FRT 4A (24-30)

1 jar due to volume

11106

FRT ZC

PROSE: 7.5

POW: 6.2

RES: 4' 9"

2-12 DK gray silty fine sand,
trace med to coarse sand to
wood FRT-ZC (2-12) PIP 0.0

12-24 Interbedded dk gray
fine sand and silt. 2 inch
lenses. FRT-ZC (12-24) PIP 0.0

24-36 SAA w/ trace wood
FRT-ZC (24-36) PIP 0.0

36-48 SAA
FRT-ZC (36-48) PIP 0.0

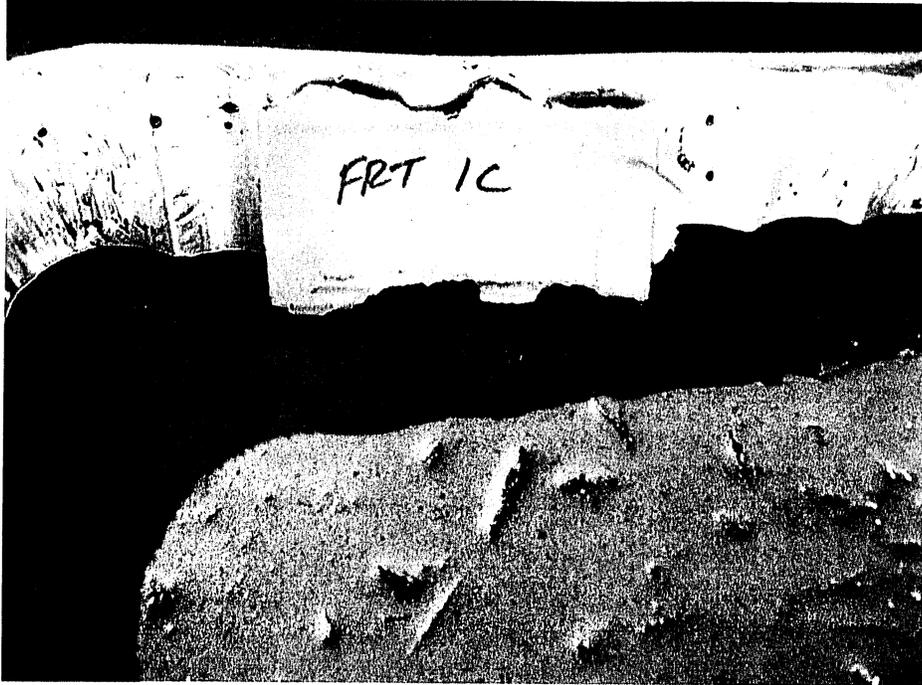
48-57 Light gray brown fine to
med sand. PIP 0.0



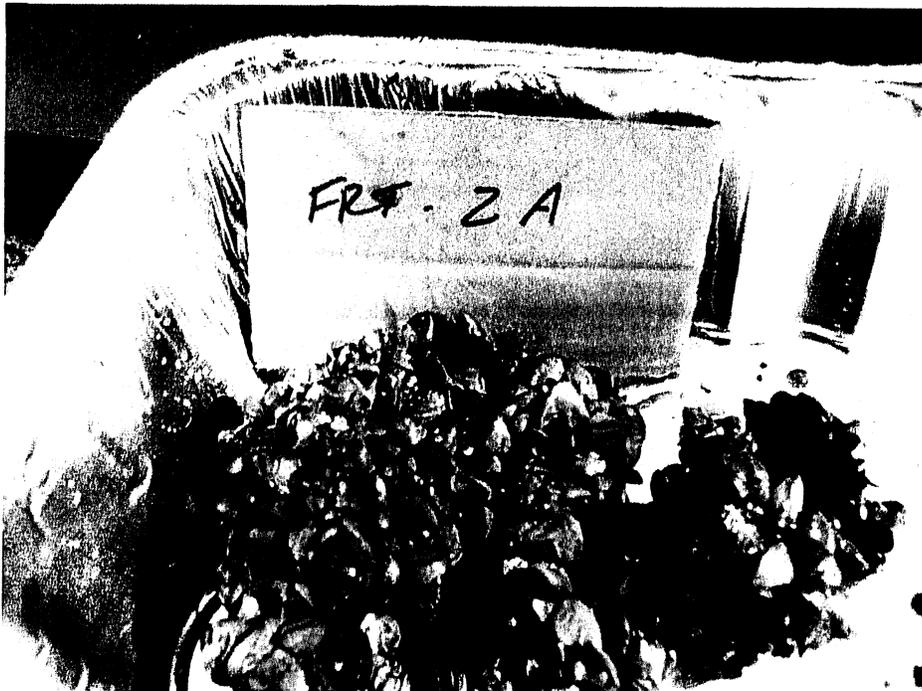
Sediment Grab Samples Collected from Transect FRT 1 Station A



Sediment Grab Samples Collected from Transect FRT 1 Station A

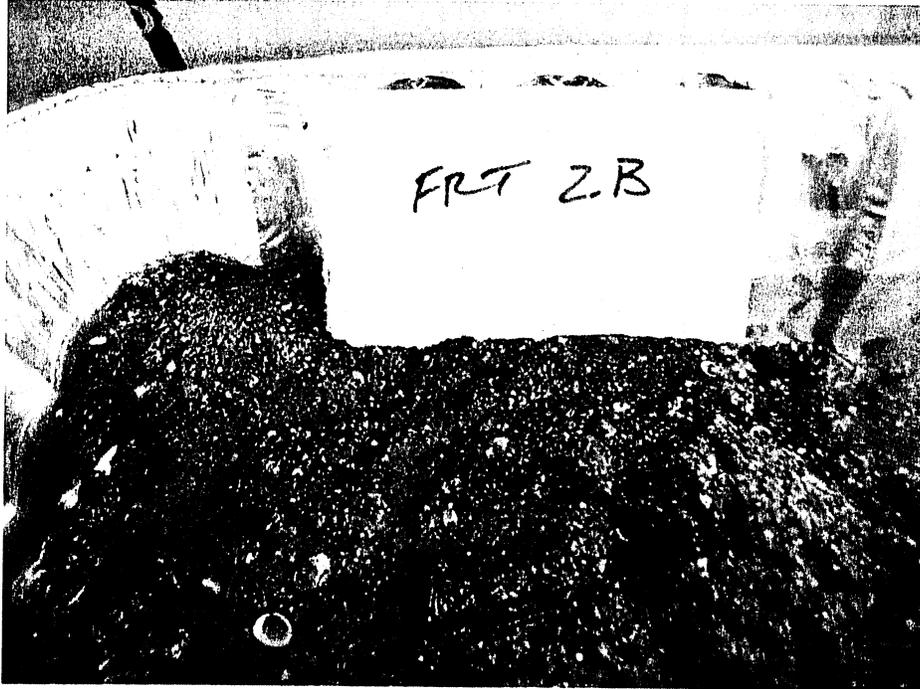


Sediment Grab Samples Collected at Transect FRT 1 Station C



Sediment Grab Samples Collected at Transect FRT 2 Station A

Flint River - Flint, Michigan
Photographs taken during October 30, 2006 to November 01, 2006

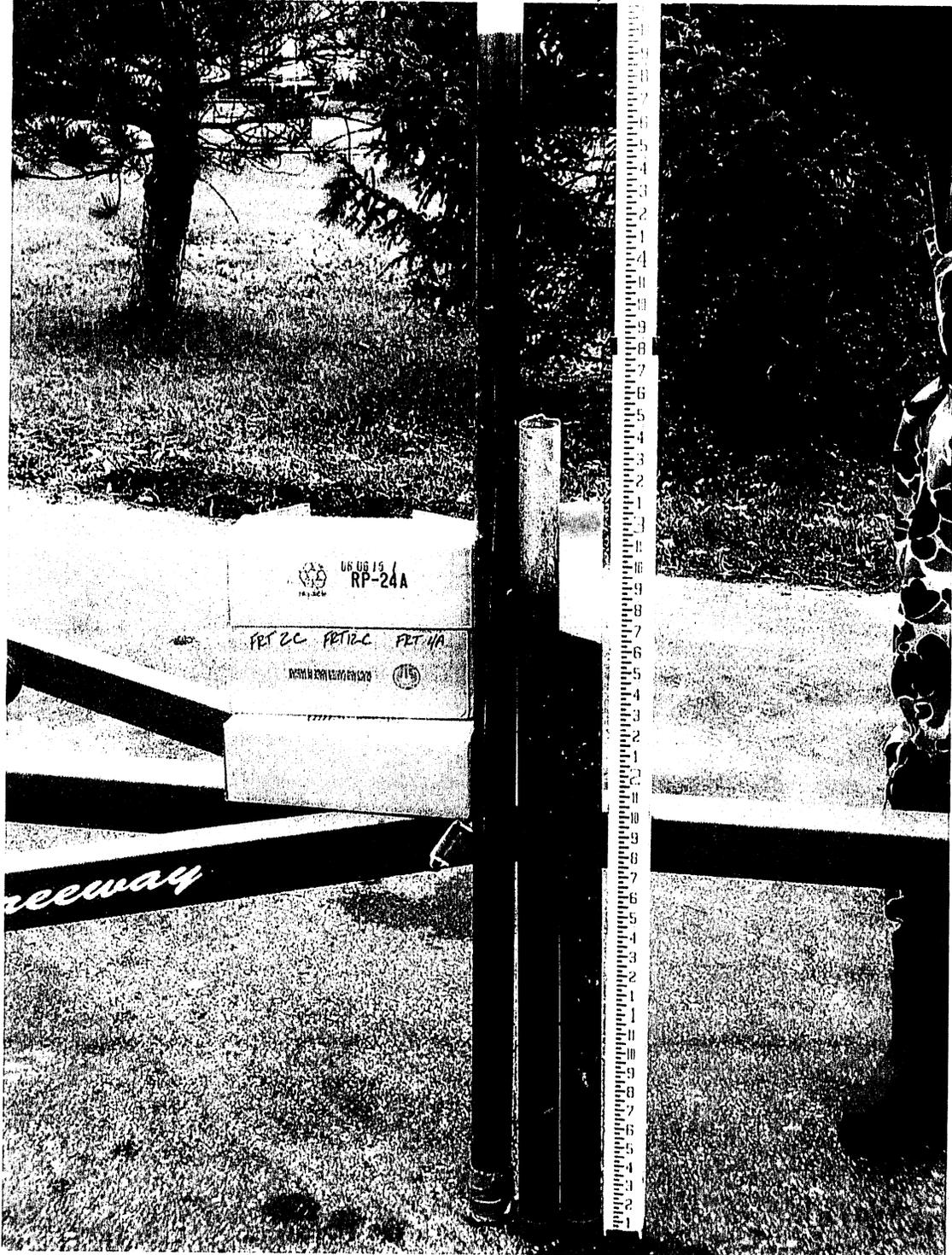


Sediment Grab Samples Collected at Transect FRT 2 Station B



Sediment Grab Samples Collected at Transect FRT 2 Station C

Flint River – Flint, Michigan
Photographs taken during October 30, 2006 to November 01, 2006



Sediment Core Samples Collected at Flint River from Transect FRT 2 Station C, Transect FRT 4 Station A, and Transect FRT 12 Station C

Flint River – Flint, Michigan
Photographs taken during October 30, 2006 to November 01, 2006



Sediment Grab Samples Collected at Transect FRT 3 Station A



Sediment Grab Samples Collected at Transect FRT 3 Station B



Sediment Grab Samples Collected at Transect FRT 3 Station C



Sediment Grab Samples Collected at Transect FRT 4 Station A

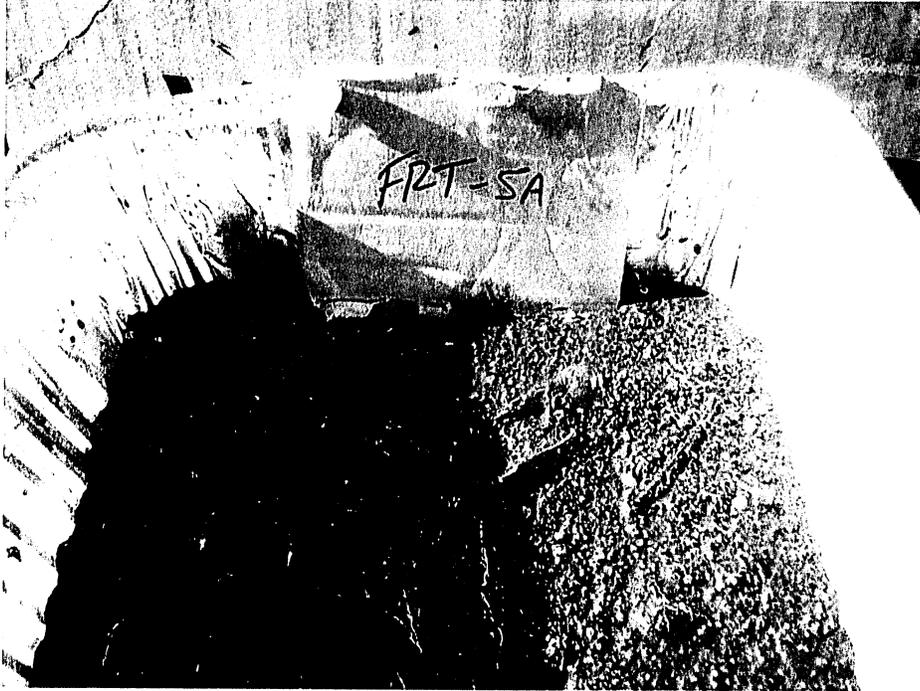


Sediment Grab Samples Collected at Transect FRT 4 Station B

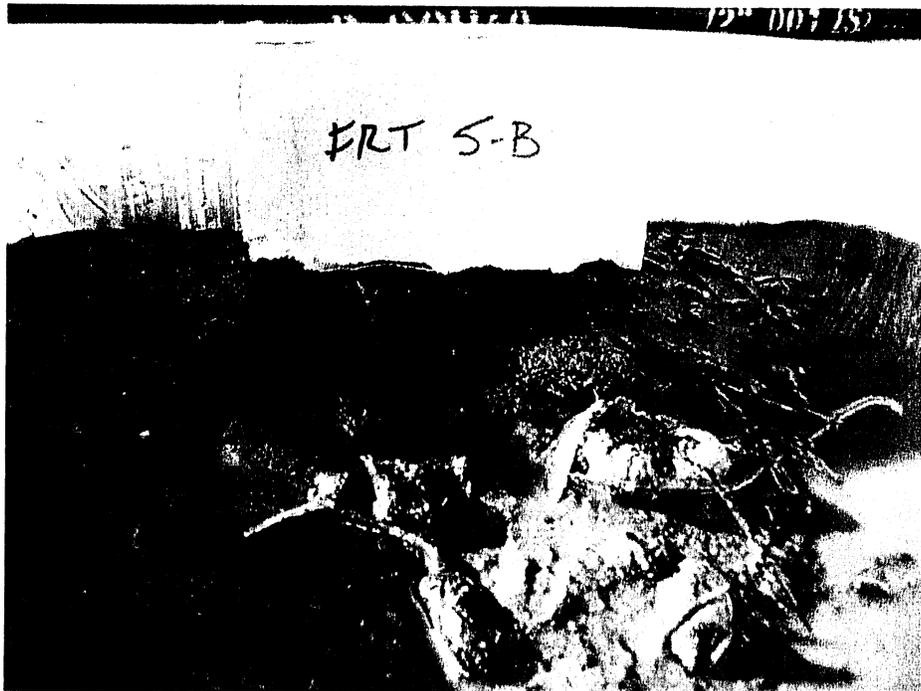


Sediment Grab Samples Collected at Transect FRT 4 Station C

Flint River – Flint, Michigan
Photographs taken during October 30, 2006 to November 01, 2006



Sediment Grab Samples Collected at Transect FRT 5 Station A

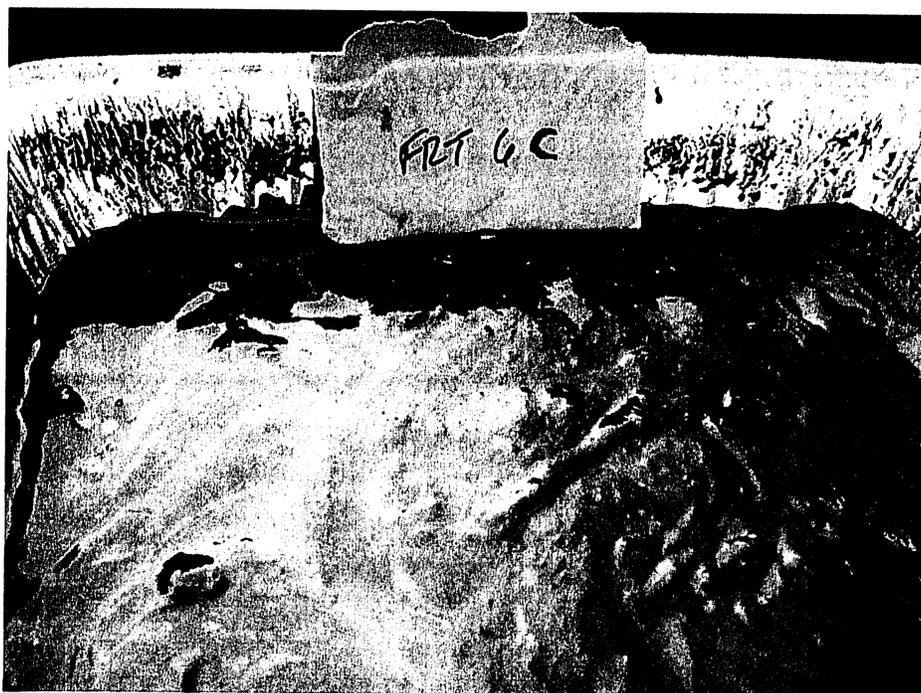


Sediment Grab Samples Collected at Transect FRT 5 Station B

Flint River - Flint, Michigan
Photographs taken during October 30, 2006 to November 01, 2006



Sediment Grab Samples Collected at Transect FRT 6 Station B



Sediment Grab Samples Collected at Transect FRT 6 Station C



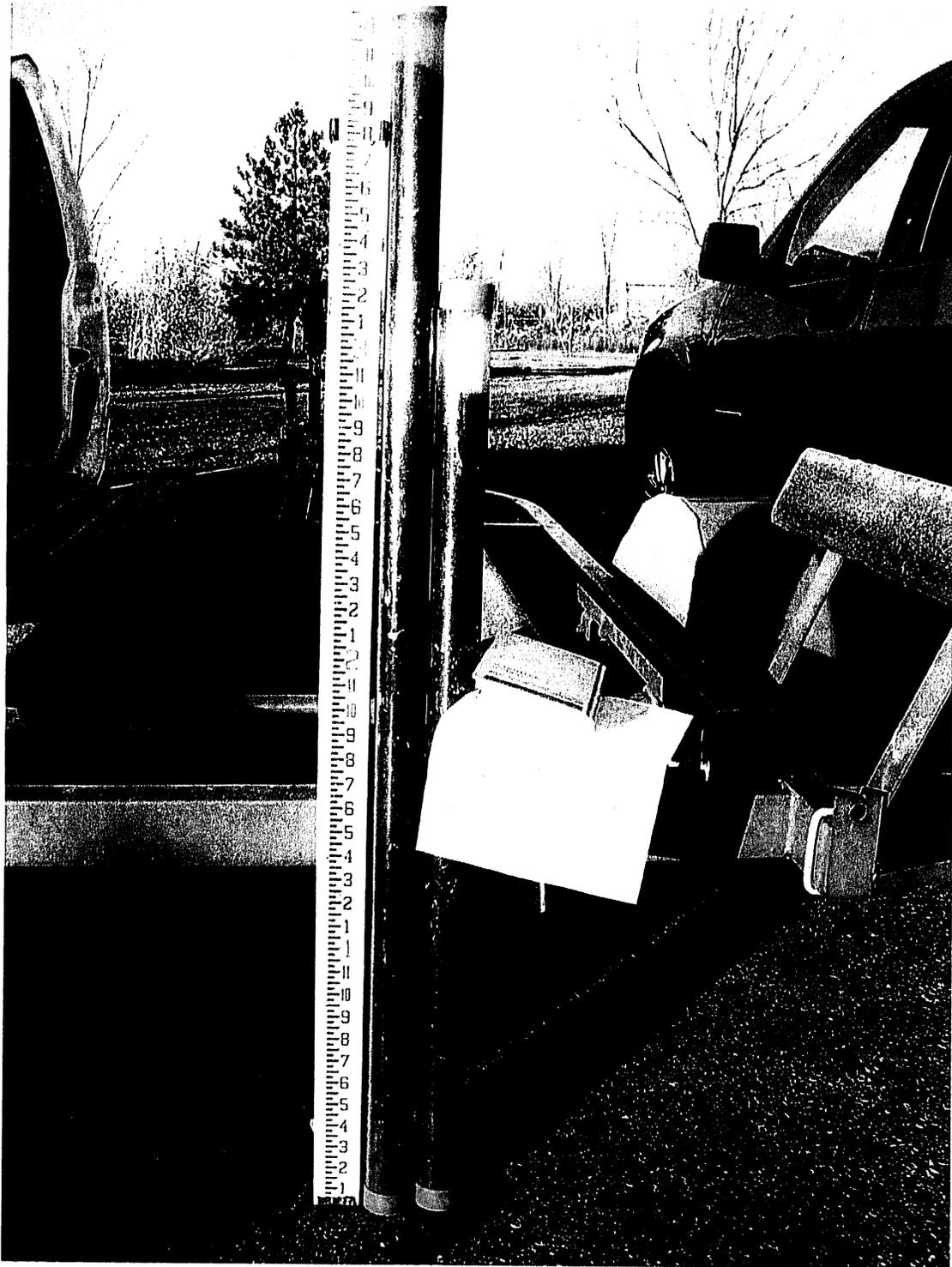
Sediment Grab Samples Collected at Transect FRT 7 Station A



Sediment Grab Samples Collected at Transect FRT 7 Station B

Flint River – Flint, Michigan

Photographs taken during October 30, 2006 to November 01, 2006



Sediment Core Samples Collected from Flint River Transect FRT 7 Station C

Flint River – Flint, Michigan
Photographs taken during October 30, 2006 to November 01, 2006



Sediment Grab Samples Collected at Transect FRT 7 Station C



Sediment Grab Samples Collected at Transect FRT 8 Station A



Sediment Grab Samples Collected at Transect FRT 8 Station B



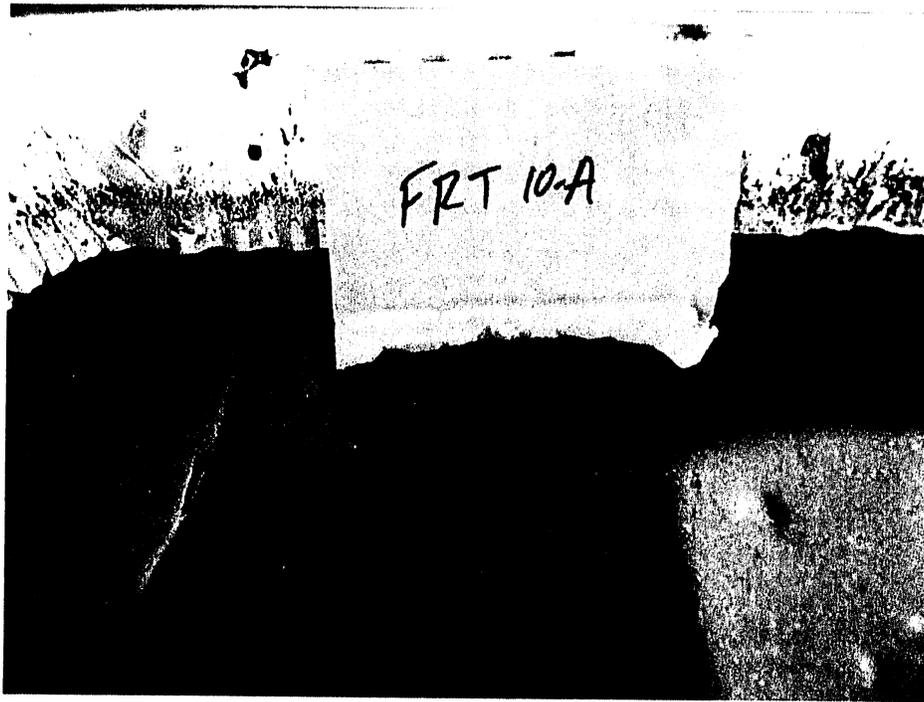
Sediment Grab Samples Collected at Transect FRT 8 Station C



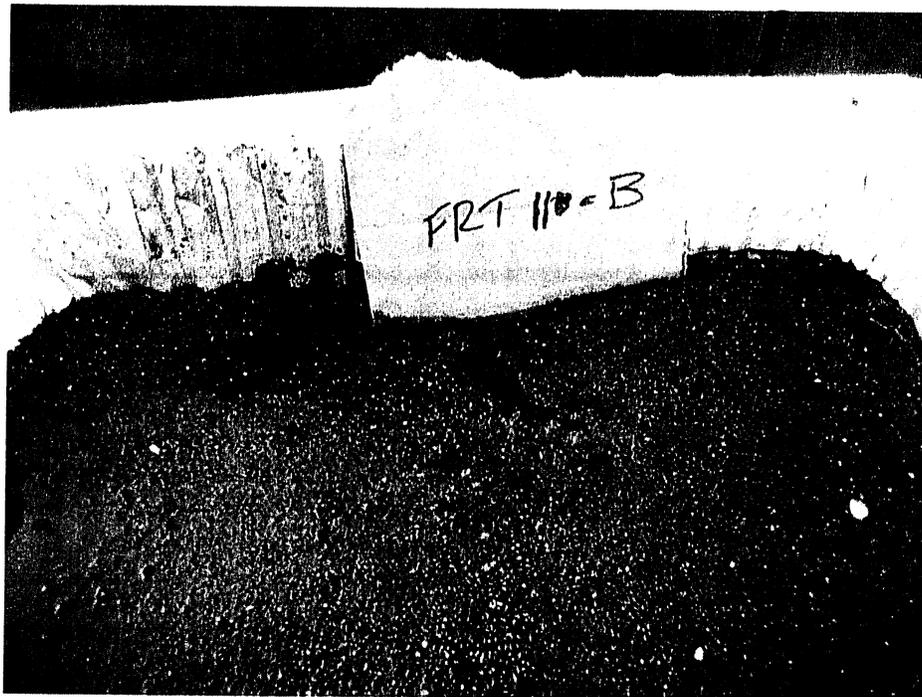
Sediment Grab Samples Collected at Transect FRT 9 Station A



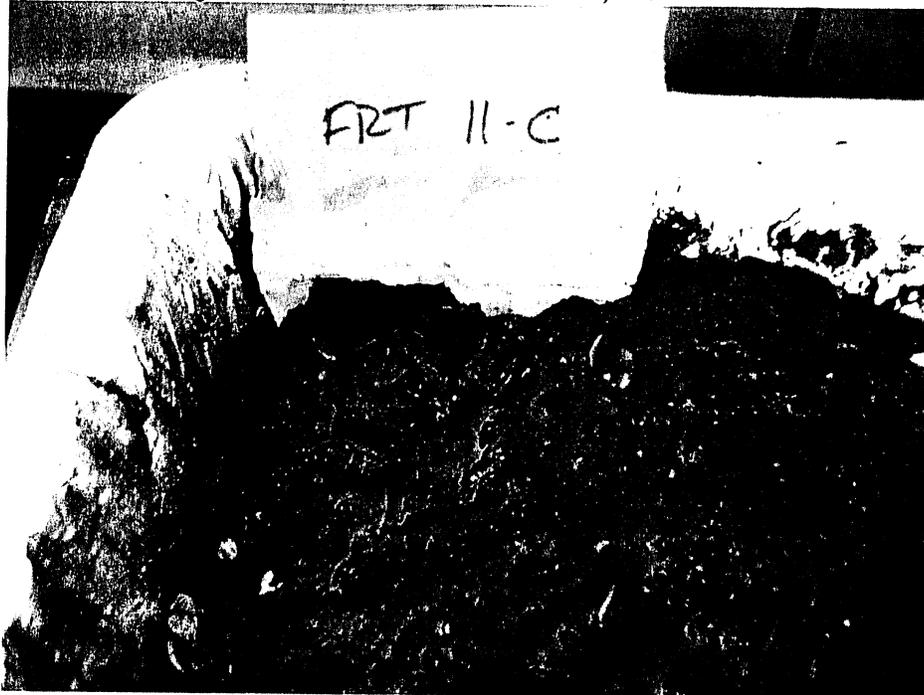
Sediment Grab Samples Collected at Transect FRT 9 Station B



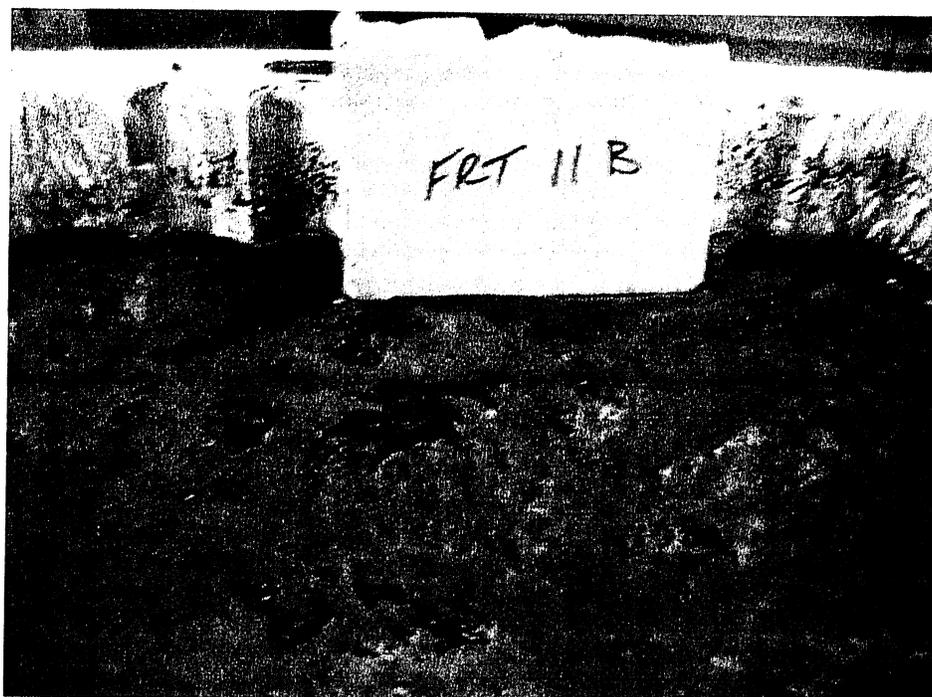
Sediment Grab Samples Collected at Transect FRT 10 Station A



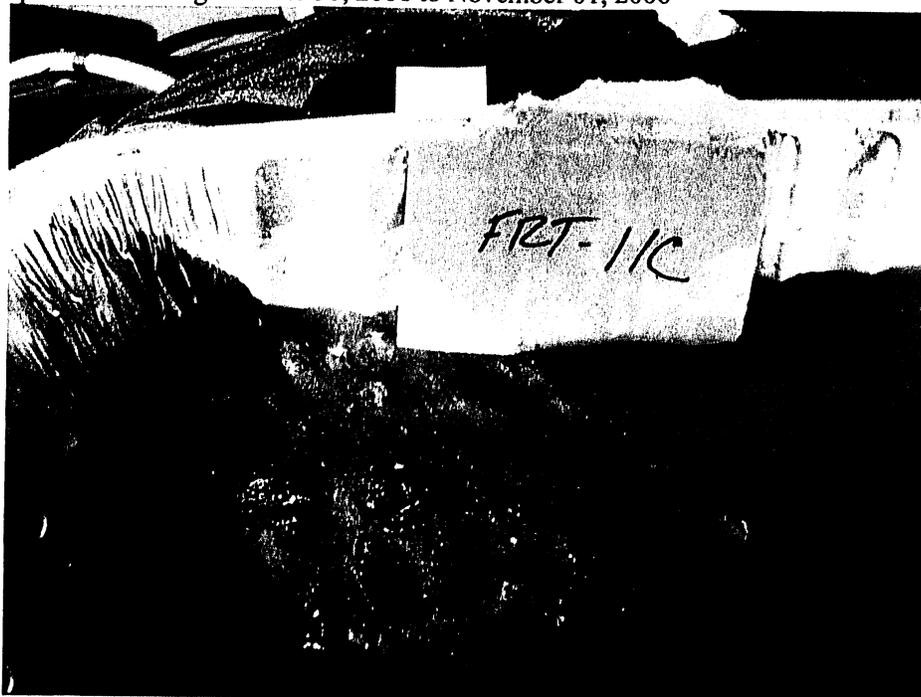
Sediment Grab Samples Collected at Transect FRT 11 Station B



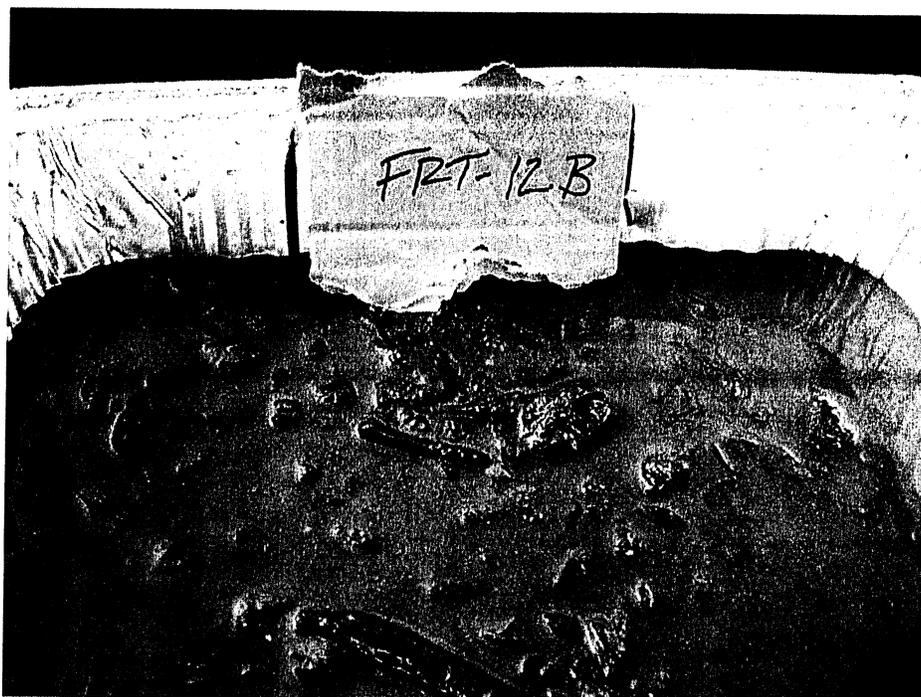
Sediment Grab Samples Collected at Transect FRT 11 Station C



Sediment Grab Samples Collected at Transect FRT 11 Station B



Sediment Grab Samples Collected at Transect FRT 11 Station C



Sediment Grab Samples Collected at Transect FRT 12 Station B

Flint River – Flint, Michigan
Photographs taken during October 30, 2006 to November 01, 2006



Sediment Grab Samples Collected at Transect FRT 12 Station C

ARCADIS BBL

Appendix B

Laboratory Validation Reports



MEMORANDUM

TO: Derek Kaiding [dck@bbl-inc.com]

REF. NO.: 017307-195017

FROM: Paul McMahon/jbh/1 *PM*

DATE: December 20, 2006

C.C.: Michael Scoville [mds@bbl-inc.com]

Send Via E-Mail and Regular Mail

RE: **Data Quality Assessment and Validation
Flint River Site Investigation
General Motors, Flint, Michigan
October-November 2006**

PREVIOUSLY TRANSMITTED
BY E-MAIL

The following details a quality assessment and validation of the analytical data resulting from the collection of 35 soil, one equipment blank, and three field duplicate samples from the General Motors Site (Site) in Flint, Michigan, from October 31 to November 1, 2006. The sample summary detailing sample identification, sample location, quality control (QC) samples, and analytical parameters is presented in Table 1. Sample analysis was completed at Merit Laboratories, Inc. in East Lansing, Michigan (Merit), in accordance with the methodologies presented in Table 2. The total organic carbon (TOC) and grain size analyses were subcontracted. The QC criteria used to assess the data were established by the methods and following documents:

- i) "USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review", United States Environmental Protection Agency (USEPA) 540/R-99/008, October 1999; and
- ii) "USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review", USEPA 540/R-94-013, February 1994.

Due to the nature of the analyses, the grain size data were not evaluated. Full Contract Laboratory Program (CLP)-equivalent raw data deliverables were provided by the laboratory for all other analyses. The data quality assessment and validation presented in the following subsections were performed based on the sample results and supporting quality assurance/quality control (QA/QC) provided.

Holding Time Period and Sample Analysis

The holding time periods are presented in the analytical methods. All samples were prepared and analyzed within the method-required holding times. All samples were cooled after collection and upon receipt at the laboratory.

Gas Chromatography/Mass Spectrometer (GC/MS) Mass Calibration

Prior to analysis, GC/MS instrumentation is tuned to ensure optimization over the mass range of interest. To evaluate instrument tuning, the semi-volatile organic compound (SVOC) method requires the analysis of

the specific tuning compound decafluorotriphenylphosphine (DFTPP). The resulting spectra must meet the criteria cited in the method before analysis is initiated. Analysis of the tuning compound must then be repeated every 12 hours throughout sample analysis to ensure the continued optimization of the instrument.

Instrument tuning data were reviewed. Tuning compounds were analyzed at the required frequency throughout the SVOC analysis periods. All tuning criteria were met for the analyses, indicating proper optimization of the instrumentation.

Initial Calibration - Organic Analyses, GC/MS

To quantify compounds of interest in samples, calibration of the GC/MS over a specific concentration range must be performed. Initially, a minimum of a five-point calibration curve containing all compounds of interest is analyzed to characterize instrument response for each analyte over a specific concentration range.

Calibration data were reviewed for all samples. Linearity of the calibration curve and instrument sensitivity were evaluated against the following criteria:

- i) all relative response factors (RRFs) must be greater than or equal to 0.05; and
- ii) percent relative standard deviation (%RSD) values must not exceed 30 percent or if quadratic/linear regression is used, the correlation coefficient (R^2) value must be at least 0.990.

Initial calibration standards were analyzed as required and all data showed acceptable sensitivity and linearity.

Initial Calibration - Organics, GC

To quantify compounds of interest, calibration of the GC over a specific concentration range must be performed. Initially, a minimum of a five-point calibration curve is analyzed for Aroclors 1254, 1016, and 1260, while the other Aroclors are calibrated using one point.

Linearity of the calibration curves are acceptable if %RSD values are less than or equal to 20 percent or if the correlation coefficient is greater than 0.995. Retention time windows are also calculated from the initial calibration analyses. These windows are then used to identify all compounds of interest in subsequent analyses.

Initial calibration standards were analyzed at the required frequencies. All retention time and linearity criteria were satisfied.

Initial Calibration - Inorganic Analyses

To calibrate the inductively coupled plasma/mass spectrometer (ICP/MS), a calibration blank and at least one standard must be analyzed at each wavelength to establish the analytical curve. For mercury, cyanide, and TOC analyses, a calibration blank and a minimum of five standards must be analyzed to establish the analytical curve. Resulting correlation coefficients for mercury, cyanide, and TOC curves must be at least 0.995.

After calibration, an initial calibration verification (ICV) standard must be analyzed to verify the analytical accuracy of the calibration curves within a method-specific percent recovery of the accepted or true value.

A review of the data showed that all calibration curves and ICVs were analyzed at the proper frequencies and were within the acceptance criteria.

Continuing Calibration - Organics, GC/MS

To ensure that instrument calibration is acceptable throughout the sample analysis period, continuing calibration standards must be analyzed and compared to the initial calibration curve every 12 hours.

The following criteria were employed to evaluate continuing calibration data:

- i) all RRF values must be greater than or equal to 0.05; and
- ii) percent difference (%D) values must not exceed 25 percent.

Calibration standards were analyzed at the required frequency and all results met the above criteria for instrument sensitivity. Some SVOCs exhibited variability in instrument response. Associated sample data for these compounds were qualified as estimated (see Table 3).

Continuing Calibration - Organics, GC

To ensure that the calibration of the instrument is valid throughout the sample analysis period, continuing calibration standards are analyzed and evaluated on a regular basis. To evaluate the continued linearity of the calibration, %D values are calculated for each compound in all continuing standards and assessed against an acceptance criterion of 15 percent.

To ensure that compound retention times do not vary over the analysis period, all retention times must fall within the established retention time windows.

Continuing calibration standards were analyzed at the required frequency and all method criteria were met for analyte linearity.

Continuing Calibration - Inorganics

Continuing calibration criteria for inorganic analyses were the same criteria as used for assessing the initial calibration data. The continuing calibration verification data were within the acceptance criteria.

Laboratory Blank Samples

Laboratory blanks are prepared and analyzed with investigative samples to determine the existence and magnitude of sample contamination introduced during the procedures.

For this study, method blanks were analyzed at a minimum frequency of one per analytical batch. The laboratory blank results were non-detect for most analytes of interest. TOC and some SVOCs were present in the laboratory blanks, and associated detected sample results with similar concentrations were qualified as non-detect (see Table 4).

Surrogate Compound Percent Recoveries (Surrogate Recoveries)

In accordance with the methods employed, all samples, blanks, and standards analyzed for SVOCs and polychlorinated biphenyls (PCBs) were spiked with surrogate compounds prior to sample extraction and analysis. Surrogate recoveries provide a means to evaluate the effects of individual sample matrices on analytical efficiency and are assessed against laboratory control limits. For the SVOC method, it is acceptable for one surrogate recovery per fraction (base neutral or acid phenolic) to fall outside of these limits, provided it is greater than 10 percent. All surrogate recoveries were within the laboratory specified control limits, demonstrating acceptable analytical accuracy.

Laboratory Control Sample (LCS) Analysis

The LCS serves as a measure of overall analytical performance. LCSs are prepared with all analytes of interest and analyzed with each sample batch.

LCSs were prepared and analyzed for all parameters. The LCS recoveries were within the laboratory specified control limits for all analytes of interest except one high and one low SVOC recovery. All SVOC results associated with the high recovery were non-detect and were not impacted by the indicated high bias. SVOC sample results associated with the low recovery were qualified as estimated (see Table 5).

Matrix Spike/Matrix Spike Duplicate (MS/MSD) Analyses

MS/MSD samples are prepared for each parameter and analyzed with each sample batch for the organic parameters. MS/MSD samples are prepared and analyzed with the samples for each inorganic analyte. The recoveries of spike analyses are used to assess the analytical accuracy achieved on individual sample matrices. If the original sample concentration is significantly greater than the spike concentration, the recovery is not assessed. The relative percent difference (RPD) between the MS and MSD is used to assess analytical precision.

MS/MSD analyses were performed as shown in Table 1. The laboratory performed additional analyses internally. Most MS/MSD recoveries were within laboratory control limits demonstrating acceptable overall analytical accuracy and precision. Outlying recoveries and RPDs were reported for PCBs and SVOCs. Non-detect results associated with outlying RPDs or high MS/MSD recoveries were not impacted, and no qualification was performed. Results impacted by outlying recoveries or RPDs were qualified as estimated (see Table 6).

Inductively Coupled Plasma (ICP) Interference Check Sample (ICS) Analysis

To verify that proper inter-element and background correction factors have been established by the laboratory, ICSs are analyzed. These samples contain high concentrations of aluminum, calcium, magnesium, and iron and are analyzed at the beginning and end of each sample analysis period.

ICS analysis results were evaluated for all samples. All ICS recoveries were within the established control limits of 80 to 120 percent.

Serial Dilution - Inorganic Analyses

The serial dilution determines whether significant physical or chemical interferences exist due to sample matrix. A minimum of one per 20 investigative samples is analyzed at a five-fold dilution. For samples with sufficient analyte concentrations, the serial dilution results must agree within 10 percent of the original results.

Serial dilution analyses were performed and most results were acceptable. Sample results associated with outlying analyses were qualified as estimated (see Table 7).

Internal Standard (IS) Summaries

To correct for changes in GC/MS response and sensitivity, IS compounds are added to investigative samples and QC samples prior to SVOC analyses. All results are calculated as a ratio of the IS response. The criteria by which the IS results are assessed are as follows:

- i) IS area counts must not vary by more than a factor of two (-50 percent to +100 percent) from the associated calibration standard; and
- ii) the retention time of the IS must not vary more than ± 30 seconds from the associated calibration standard.

All sample IS results met the above criteria and all were correctly used to calculate sample results.

Target Compound Identification

To minimize erroneous compound identification during organic analyses, qualitative criteria including compound retention time and mass spectra (if applicable) were evaluated according to identification criteria established by the methods. The samples identified in Table 1 were reviewed. The organics reported adhered to the specified identification criteria.

Field Duplicates

Three samples were collected in duplicate as summarized in Table 1 and submitted to the laboratory for analysis. Most sample results showed acceptable sampling and analytical precision. Some data did exhibit variability, and the results were qualified as estimated (see Table 8).

Equipment Blank

To assess contamination from field equipment cleaning activities, equipment blank was collected in as identified in Table 1. Most sample results were non-detect for the analytes of interest. SVOCs and some inorganics were detected in the blank. Most associated sample results were either non-detect or were significantly greater in concentration, and were not impacted. Associated sample results with comparable concentrations were qualified as non-detect (see Table 9).

System Performance

System performance between various QC checks was evaluated to monitor for changes that may have caused the degradation of data quality. The samples identified in Table 1 were reviewed. No technical problems or chromatographic anomalies were observed which require qualification of the data.

Overall Assessment

The data were found to exhibit acceptable levels of accuracy and precision, based on the provided information, and may be used as reported with the noted qualifications.

TABLE 1
SAMPLE COLLECTION AND ANALYSIS SUMMARY
SITE INVESTIGATION
GENERAL MOTORS
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

Sample ID	Location ID	Collection Date (mm/dd/yy)	Collection Time (hr:min)	Analysis/Parameters				Comments
				TOC/Particle size	Total Metals/Cyanide	SVOCs	PCBs	
FRT 1C	FRT 1C	11/01/06	12:00	X	X	X	X	
FRT 2B	FRT 2B	11/01/06	11:20	X	X	X	X	
FRT 2C	FRT 2C	11/01/06	11:30	X	X	X	X	
FRT 3A	FRT 3A	11/01/06	10:40	X	X	X	X	
FRT 3B	FRT 3B	11/01/06	10:35	X	X	X	X	
FRT 4A	FRT 4A	11/01/06	9:45	X	X	X	X	
FRT 4C	FRT 4C	11/01/06	9:35	X	X	X	X	
FRT 5A	FRT 5A	10/31/06	15:03	X	X	X	X	
FRT 5B	FRT 5B	10/31/06	15:03	X	X	X	X	
FRT 6B	FRT 6B	10/31/06	14:30	X	X	X	X	
FRT 7A	FRT 7A	10/31/06	12:30	X	X	X	X	
FRT 7C	FRT 7C	10/31/06	12:10	X	X	X	X	MS/MSD /Duplicate
FRT 8B	FRT 8B	10/31/06	9:10	X	X	X	X	
FRT 9A	FRT 9A	10/31/06	8:30	X	X	X	X	
FRT DUP1	FRT 9A	10/31/06	-	X	X	X	X	Duplicate of FRT 9A
FRT 9B	FRT 9B	10/31/06	8:10	X	X	X	X	
FRT 10B	FRT 10B	10/31/06	15:45	X	X	X	X	
FRT 11B	FRT 11B	11/01/06	9:00	X	X	X	X	
FRT DUP3	FRT 11B	11/01/06	-	X	X	X	X	Duplicate of FRT 11B
FRT 11C	FRT 11C	11/01/06	9:05	X	X	X	X	
FRT 12B	FRT 12B	10/31/06	13:37	X	X	X	X	
FRT 12C	FRT 12C	10/31/06	13:30	X	X	X	X	
FRT RB1	-	11/01/06	17:00		X	X	X	Equipment Blank
FRT 10A	FRT 10A	11/01/06	15:35	X	X	X	X	
FRT 7C (2-12)	FRT 7C	10/31/06	12:40	X	X	X	X	
FRT DUP2	FRT 7C	11/01/06	-	X	X	X	X	Duplicate of FRT 7C (2-12)
FRT 7C (12-24)	FRT 7C	10/31/06	12:40	X	X	X	X	
FRT 7C (24-36)	FRT 7C	10/31/06	12:40	X	X	X	X	MS/MSD /Duplicate
FRT 7C (36-46)	FRT 7C	10/31/06	12:40	X	X	X	X	
FRT 4A (2-12)	FRT 4A	11/01/06	12:45	X	X	X	X	
FRT 4A (12-24)	FRT 4A	11/01/06	12:45	X	X	X	X	
FRT 12C (2-12)	FRT 12C	11/01/06	13:00	X	X	X	X	
FRT 12C (12-24)	FRT 12C	11/01/06	13:00	X	X	X	X	
FRT 12C (24-36)	FRT 12C	11/01/06	13:00	X	X	X	X	
FRT 2C (2-12)	FRT 2C	11/01/06	12:30	X	X	X	X	
FRT 2C (12-24)	FRT 2C	11/01/06	12:30	X	X	X	X	
FRT 2C (24-36)	FRT 2C	11/01/06	12:30	X	X	X	X	
FRT 2C (36-48)	FRT 2C	11/01/06	12:30	X	X	X	X	
FRT 2C (48-57)	FRT 2C	11/01/06	12:30	X	X	X	X	

Notes:
MS Matrix Spike.
MSD Matrix Spike Duplicate.
PCBs Polychlorinated biphenyls.
SVOCs Semi-Volatile Organic Compounds.
TOC Total Organic Carbon.

TABLE 2
SUMMARY OF ANALYTICAL METHODOLOGIES
SITE INVESTIGATION
GENERAL MOTORS
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

<i>Parameter</i>	<i>Method</i>
TCL SVOCs	SW-846 8270 ¹
TCL PCBs	SW-846 8082 ¹
Metals	SW-846 6020 ¹ /7471 ¹
Cyanide	SW-846 9010 ¹
TOC	415.1 ²
Particle Size	ASTM F312

Notes:

- ¹ "Test Methods for Solid Waste Physical/Chemical Methods", SW-846, 3rd Edition, September 1986 (with subsequent revisions).
- ² Referenced from "Methods for Chemical Analysis of Water and Wastes", USEPA 600/4-79-020, March 1983, with all subsequent revisions.
- ASTM American Society for Testing and Materials.
 PCBs Polychlorinated Biphenyls.
 TCL Target Compound List.
 TOC Total Organic Carbon.

TABLE 3
QUALIFIED SAMPLE RESULTS DUE TO OUTLYING CONTINUING CALIBRATION RESULTS
SITE INVESTIGATION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

<i>Parameter</i>	<i>Calibration Date</i>	<i>Compound</i>	<i>%D</i>	<i>Associated Sample ID</i>	<i>Sample Results</i>	<i>Units</i>	<i>Qualifier</i>
SVOCs	11/11/06	Benzaldehyde	38	FRT 2C (36-48)	330 U	µg/Kg	UJ
				FRT 2C (48-57)	330 U	µg/Kg	UJ
		2,4-Dinitrophenol	27	FRT 2C (36-48)	670 U	µg/Kg	UJ
				FRT 2C (48-57)	670 U	µg/Kg	UJ
		Benzo(b)fluoranthene	58	FRT 2C (36-48)	330 U	µg/Kg	UJ
				FRT 2C (48-57)	330 U	µg/Kg	UJ
		Benzo(K)fluoranthene	58	FRT 2C (36-48)	330 U	µg/Kg	UJ
				FRT 2C (48-57)	330 U	µg/Kg	UJ
SVOCs	11/11/06	Benzo(K)fluoranthene	30	FRT 10B	330 U	µg/Kg	UJ
				FRT 1C	330 U	µg/Kg	UJ
				FRT 2B	330 U	µg/Kg	UJ
				FRT 3A	330 U	µg/Kg	UJ
				FRT 3B	330 U	µg/Kg	UJ
				FRT 4A	200 J	µg/Kg	J
				FRT 4C	530	µg/Kg	J
				FRT 5A	200 J	µg/Kg	J
				FRT 6B	70 J	µg/Kg	J
				FRT 7A	300 J	µg/Kg	J
				FRT 7C	820	µg/Kg	J
				FRT 8B	330 U	µg/Kg	UJ
				FRT 9A	1580	µg/Kg	J
				FRT 9B	880	µg/Kg	J
				SVOCs	11/11/06	2,4-Dinitrophenol	26
FRT 1C	670 U	µg/Kg	UJ				
FRT 2B	670 U	µg/Kg	UJ				
FRT 3A	670 U	µg/Kg	UJ				
FRT 3B	670 U	µg/Kg	UJ				
FRT 4A	670 U	µg/Kg	UJ				
FRT 4C	670 U	µg/Kg	UJ				
FRT 5A	670 U	µg/Kg	UJ				
FRT 6B	670 U	µg/Kg	UJ				
FRT 7A	670 U	µg/Kg	UJ				
FRT 7C	670 U	µg/Kg	UJ				
FRT 8B	670 U	µg/Kg	UJ				
FRT 9A	670 U	µg/Kg	UJ				
FRT 9B	670 U	µg/Kg	UJ				
SVOCs	11/11/06	Benzo(b)fluoranthene	47				
				FRT 1C	330 U	µg/Kg	UJ
				FRT 2B	330 U	µg/Kg	UJ
				FRT 3A	330 U	µg/Kg	UJ
				FRT 3B	330 U	µg/Kg	UJ
				FRT 4A	200 J	µg/Kg	J
				FRT 4C	750	µg/Kg	J
				FRT 5A	330 U	µg/Kg	UJ
				FRT 6B	330 U	µg/Kg	UJ
				FRT 7A	300 J	µg/Kg	J
				FRT 7C	890	µg/Kg	J
				FRT 8B	330 U	µg/Kg	UJ
				FRT 9A	2090	µg/Kg	J
				FRT 9B	1320	µg/Kg	J

TABLE 3
 QUALIFIED SAMPLE RESULTS DUE TO OUTLYING CONTINUING CALIBRATION RESULTS
 SITE INVESTIGATION
 GENERAL MOTORS CORPORATION
 FLINT, MICHIGAN
 OCTOBER - NOVEMBER 2006

Parameter	Calibration Date	Compound	%D	Associated Sample ID	Sample Results	Units	Qualifier
SVOCs	11/13/06	Benzaldehyde	29	FRT 10A	330 U	µg/Kg	UJ
				FRT 11C	330 U	µg/Kg	UJ
				FRT 12B	330 U	µg/Kg	UJ
				FRT 12C	330 U	µg/Kg	UJ
				FRT 12C (12-24)	330 U	µg/Kg	UJ
				FRT 12C (2-12)	330 U	µg/Kg	UJ
				FRT 12C (24-36)	330 U	µg/Kg	UJ
				FRT 4A (12-24)	330 U	µg/Kg	UJ
				FRT 4A (2-12)	330 U	µg/Kg	UJ
				FRT 7C (12-24)	1000 U	µg/Kg	UJ
				FRT 7C (2-12)	1000 U	µg/Kg	UJ
				FRT 7C (24-36)	330 U	µg/Kg	UJ
				FRT 7C (36-46)	330 U	µg/Kg	UJ
				FRT DUP1	330 U	µg/Kg	UJ
				FRT DUP2	1000 U	µg/Kg	UJ
				FRT DUP3	330 U	µg/Kg	UJ
				SVOCs	11/13/06	Hexachlorocyclopentadiene	42
FRT 11C	330 U	µg/Kg	UJ				
FRT 12B	330 U	µg/Kg	UJ				
FRT 12C	330 U	µg/Kg	UJ				
FRT 12C (12-24)	330 U	µg/Kg	UJ				
FRT 12C (2-12)	330 U	µg/Kg	UJ				
FRT 12C (24-36)	330 U	µg/Kg	UJ				
FRT 4A (12-24)	330 U	µg/Kg	UJ				
FRT 4A (2-12)	330 U	µg/Kg	UJ				
FRT 7C (12-24)	1000 U	µg/Kg	UJ				
FRT 7C (2-12)	1000 U	µg/Kg	UJ				
FRT 7C (24-36)	330 U	µg/Kg	UJ				
FRT 7C (36-46)	330 U	µg/Kg	UJ				
FRT DUP1	330 U	µg/Kg	UJ				
FRT DUP2	1000 U	µg/Kg	UJ				
FRT DUP3	330 U	µg/Kg	UJ				
SVOCs	11/13/06	Benzo(b)fluoranthene	47				
				FRT 11C	300 J	µg/Kg	J
				FRT 12B	300 J	µg/Kg	J
				FRT 12C	880	µg/Kg	J
				FRT 12C (12-24)	1180	µg/Kg	J
				FRT 12C (2-12)	2200	µg/Kg	J
				FRT 12C (24-36)	300 J	µg/Kg	J
				FRT 4A (12-24)	330 U	µg/Kg	UJ
				FRT 4A (2-12)	100 J	µg/Kg	J
				FRT 7C (12-24)	4000	µg/Kg	J
				FRT 7C (2-12)	2000	µg/Kg	J
				FRT 7C (24-36)	300 J	µg/Kg	J
				FRT 7C (36-46)	330 U	µg/Kg	UJ
				FRT DUP1	1280	µg/Kg	J
				FRT DUP2	1000	µg/Kg	J
				FRT DUP3	640	µg/Kg	J
				SVOCs	11/13/06	Benzo(k)fluoranthene	59
FRT 11C	200 J	µg/Kg	J				
FRT 12B	300 J	µg/Kg	J				
FRT 12C	750	µg/Kg	J				
FRT 12C (12-24)	930	µg/Kg	J				
FRT 12C (2-12)	1450	µg/Kg	J				
FRT 12C (24-36)	200 J	µg/Kg	J				
FRT 4A (12-24)	330 U	µg/Kg	UJ				
FRT 4A (2-12)	100 J	µg/Kg	J				

TABLE 3
QUALIFIED SAMPLE RESULTS DUE TO OUTLYING CONTINUING CALIBRATION RESULTS
SITE INVESTIGATION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

<i>Parameter</i>	<i>Calibration Date</i>	<i>Compound</i>	<i>%D</i>	<i>Associated Sample ID</i>	<i>Sample Results</i>	<i>Units</i>	<i>Qualifier</i>
SVOCs (Cont'd.)	11/13/06	Benzo(k)fluoranthene	59	FRT 7C (12-24)	4000	µg/Kg	J
				FRT 7C (2-12)	1000	µg/Kg	J
				FRT 7C (24-36)	300 J	µg/Kg	J
				FRT 7C (36-46)	330 U	µg/Kg	UJ
				FRT DUP1	1090	µg/Kg	J
				FRT DUP2	800	µg/Kg	J
				FRT DUP3	470	µg/Kg	J
SVOCs	11/14/06	Benzo(b)fluoranthene	46	FRT 2C	330 U	µg/Kg	UJ
				FRT 2C (12-24)	330 U	µg/Kg	UJ
				FRT 2C (2-12)	330 U	µg/Kg	UJ
				FRT 2C (24-36)	330 U	µg/Kg	UJ
				FRT 5B	220 J	µg/Kg	J
SVOCs	11/14/06	Benzo(K)fluoranthene	46	FRT 2C	330 U	µg/Kg	UJ
				FRT 2C (12-24)	330 U	µg/Kg	UJ
				FRT 2C (2-12)	330 U	µg/Kg	UJ
				FRT 2C (24-36)	330 U	µg/Kg	UJ
				FRT 5B	220 J	µg/Kg	J

Notes:

% D Percent Difference.

J Estimated.

SVOCs Semi-Volatile Organic Compounds.

U Non-detect at associated value.

UJ The analyte was not detected above the sample quantitation limit. The reported quantitation limit is an estimated quantity.

TABLE 4
QUALIFIED SAMPLE RESULTS DUE TO ANALYTE CONCENTRATIONS IN THE LABORATORY BLANKS
SITE INVESTIGATION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

<i>Parameter</i>	<i>Analysis Date</i>	<i>Analyte</i>	<i>Blank Result</i>	<i>Sample ID</i>	<i>Sample Result</i>	<i>Qualified Sample Result</i>	<i>Units</i>
SVOCs	11/08/06	Di-n-butylphthalate	35J	FRT 2C	60 J	330 U	µg/Kg
				FRT 5B	60 J	330 U	µg/Kg
				FRT 12C	70 J	330 U	µg/Kg
				FRT 2C (12-24)	30 J	330 U	µg/Kg
				FRT 2C (2-12)	40 J	330 U	µg/Kg
				FRT 2C (24-36)	40 J	330 U	µg/Kg
SVOCs	11/08/06	bis(2-Ethylhexyl)phthalate	137J	FRT 3A	100 J	330 U	µg/Kg
				FRT 3B	60 J	330 U	µg/Kg
				FRT 4C	100 J	330 U	µg/Kg
				FRT 5B	200 J	330 U	µg/Kg
				FRT 7A	300 J	330 U	µg/Kg
				FRT 7C	510 J	510 U	µg/Kg
				FRT 8B	60 J	330 U	µg/Kg
				FRT 9A	760	760 U	µg/Kg
SVOCs	11/08/06	Benzo(b)fluoranthene	20J	FRT 5A	100 J	330 U	µg/Kg
				FRT 6B	70 J	330 U	µg/Kg
				FRT 8B	100 J	330 U	µg/Kg
				FRT 10B	100 J	330 U	µg/Kg
SVOCs	11/08/06	Benzo(K)fluoranthene	27J	FRT 10B	100 J	330 U	µg/Kg
				FRT 8B	70 J	330 U	µg/Kg
SVOCs	11/08/06	Benzo(a)pyrene	20J	FRT 6B	70 J	330 U	µg/Kg
SVOCs	11/09/06	Di-n-butylphthalate	51J	FRT 2C (36-48)	30 J	330 U	µg/Kg
SVOCs	11/09/06	bis(2-Ethylhexyl)phthalate	580	FRT 2C (36-48)	60 J	330 U	µg/Kg
				FRT 2C (48-57)	30 J	330 U	µg/Kg
SVOCs	11/08/06	Diethyl phthalate	35J	FRT 12C	100 J	330 U	µg/Kg
				FRT 12C (2-12)	70 J	330 U	µg/Kg
				FRT 2C (12-24)	40 J	330 U	µg/Kg
				FRT 2C (2-12)	40 J	330 U	µg/Kg
				FRT 2C (24-36)	50 J	330 U	µg/Kg
				FRT DUP1	70 J	330 U	µg/Kg
TOC	11/16/06	Total Organic Carbon	3.6J	FRT 2C (48-57)	10 J	12 U	mg/kg
				FRT 8B	15	15 U	mg/kg

Notes:

- J Estimated.
- SVOCs Semi-Volatile Organic Compounds.
- TOC Total Organic Carbon.
- U Non-detect at associated value.

TABLE 5
QUALIFIED SAMPLE RESULTS DUE TO OUTLYING LABORATORY CONTROL SAMPLE RESULTS
SITE INVESTIGATION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

<i>Parameter</i>	<i>Compound</i>	<i>Preparation Date</i>	<i>Percent Recovery</i>	<i>Control Limits (percent)</i>	<i>Associated Sample ID</i>	<i>Sample Results</i>	<i>Units</i>	<i>Qualifier</i>
SVOCs	N-Nitrosodiphenylamine	11/08/06	26	39 - 138	FRT 10A	330 U	µg/Kg	UJ
					FRT 10B	330 U	µg/Kg	UJ
					FRT 11B	330 U	µg/Kg	UJ
					FRT 11C	330 U	µg/Kg	UJ
					FRT 12B	330 U	µg/Kg	UJ
					FRT 12C	330 U	µg/Kg	UJ
					FRT 12C (12-24)	330 U	µg/Kg	UJ
					FRT 12C (2-12)	330 U	µg/Kg	UJ
					FRT 12C (24-36)	330 U	µg/Kg	UJ
					FRT 1C	330 U	µg/Kg	UJ
					FRT 2B	330 U	µg/Kg	UJ
					FRT 2C	330 U	µg/Kg	UJ
					FRT 2C (12-24)	330 U	µg/Kg	UJ
					FRT 2C (2-12)	330 U	µg/Kg	UJ
					FRT 2C (24-36)	330 U	µg/Kg	UJ
					FRT 3A	330 U	µg/Kg	UJ
					FRT 3B	330 U	µg/Kg	UJ
					FRT 4A	330 U	µg/Kg	UJ
					FRT 4A (12-24)	330 U	µg/Kg	UJ
					FRT 4A (2-12)	330 U	µg/Kg	UJ
					FRT 4C	330 U	µg/Kg	UJ
					FRT 5A	330 U	µg/Kg	UJ
					FRT 5B	330 U	µg/Kg	UJ
					FRT 6B	330 U	µg/Kg	UJ
					FRT 7A	330 U	µg/Kg	UJ
					FRT 7C	330 U	µg/Kg	UJ
					FRT 7C (12-24)	1000 U	µg/Kg	UJ
					FRT 7C (2-12)	1000 U	µg/Kg	UJ
					FRT 7C (24-36)	330 U	µg/Kg	UJ
					FRT 7C (36-46)	330 U	µg/Kg	UJ
					FRT 8B	330 U	µg/Kg	UJ
					FRT 9A	330 U	µg/Kg	UJ
					FRT 9B	330 U	µg/Kg	UJ
					FRT DUP1	330 U	µg/Kg	UJ
					FRT DUP2	1000 U	µg/Kg	UJ
					FRT DUP3	330 U	µg/Kg	UJ

Notes:

SVOCs Semi-Volatile Organic Compounds.

U Non-detect at associated value.

UJ The analyte was not detected above the sample quantitation limit. The reported quantitation limit is an estimated quantity.

TABLE 6
QUALIFIED SAMPLE RESULTS DUE TO OUTLYING MATRIX SPIKE/MATRIX SPIKE DUPLICATE RECOVERIES
SITE INVESTIGATION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

Parameter	Associated Sample ID	Analyte	MS Recovery (percent)	MSD Recovery (percent)	RPD (percent)	Control Limits		Sample Result	Units	Qualifier
						Recovery (percent)	RPD (percent)			
PCBs	FRT 7C	Aroclor 1260	59	112	46	53 - 123	20	20 J	µg/Kg	J
SVOC	FRT 7C	all SVOCs	variable	variable	>25	variable	25	Variable	µg/Kg	J
	FRT 7C (12-24)	Benzaldehyde	27	48	55	37 - 126	25	1000 U	µg/Kg	UJ
		Hexachloroethane	11	15	23	35 - 120	25	1000 U	µg/Kg	UJ
		Acenaphthene	127	129	2	37 - 124	25	800 J	µg/Kg	J
		Benzo(b)fluoranthene	183	171	4	29 - 153	25	4000	µg/Kg	J
		Indeno(1,2,3-cd)pyrene	156	171	6	39 - 137	25	3000	µg/Kg	J
		Benzo(g,h,i)perylene	142	163	9	45 - 131	25	3000	µg/Kg	J

Notes

- J Estimated.
- MS Matrix Spike.
- MSD Matrix Spike Duplicate.
- PCBs Polychlorinated Biphenyls.
- RPD Relative Percent Difference.
- SVOCs Semi-Volatile Organic Compounds.
- U Non-detect at associated value.
- UJ The analyte was not detected above the sample quantitation limit. The reported quantitation limit is an estimated quantity.

TABLE 7
QUALIFIED SAMPLE RESULTS DUE TO OUTLYING SERIAL DILUTION RESULTS
SITE INVESTIGATION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

<i>Parameter</i>	<i>Analyte</i>	<i>Serial Dilution Sample ID</i>	<i>%D</i>	<i>Associated Samples</i>	<i>Sample Results</i>	<i>Units</i>	<i>Qualifier</i>
Metals	Barium	FRT 1C	23	FRT 10B	14.9	mg/Kg	J
				FRT 11B	18.8	mg/Kg	J
				FRT 11C	18.5	mg/Kg	J
				FRT 12B	30.9	mg/Kg	J
				FRT 12C	146	mg/Kg	J
				FRT 1C	18.3	mg/Kg	J
				FRT 2B	7.5	mg/Kg	J
				FRT 2C	90.6	mg/Kg	J
				FRT 3A	11.2	mg/Kg	J
				FRT 3B	7.5	mg/Kg	J
				FRT 4A	28.9	mg/Kg	J
				FRT 4C	73.2	mg/Kg	J
				FRT 5A	20.2	mg/Kg	J
				FRT 5B	22.8	mg/Kg	J
				FRT 6B	19.4	mg/Kg	J
				FRT 7A	29.4	mg/Kg	J
				FRT 7C	38.8	mg/Kg	J
				FRT 8B	26.1	mg/Kg	J
				FRT 9A	127	mg/Kg	J
				FRT 9B	52.6	mg/Kg	J
Metals	Zinc	FRT 1C	15	FRT 10B	18.1	mg/Kg	J
				FRT 11B	42.4	mg/Kg	J
				FRT 11C	25.4	mg/Kg	J
				FRT 12B	62.0	mg/Kg	J
				FRT 12C	316	mg/Kg	J
				FRT 1C	11.7	mg/Kg	J
				FRT 2B	8.2	mg/Kg	J
				FRT 2C	42.9	mg/Kg	J
				FRT 3A	10.9	mg/Kg	J
				FRT 3B	8.2	mg/Kg	J
				FRT 4A	28.2	mg/Kg	J
				FRT 4C	72.3	mg/Kg	J
				FRT 5A	43.1	mg/Kg	J
				FRT 5B	37.6	mg/Kg	J
				FRT 6B	30.6	mg/Kg	J
				FRT 7A	49.8	mg/Kg	J
				FRT 7C	94.0	mg/Kg	J
				FRT 8B	30.8	mg/Kg	J
				FRT 9A	324	mg/Kg	J
				FRT 9B	312	mg/Kg	J

Notes:

%D Percent Difference.
J Estimated.

TABLE 8
QUALIFIED SAMPLE RESULTS DUE TO VARIABILITY IN FIELD DUPLICATE RESULTS
SITE INVESTIGATION
GENERAL MOTORS
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

<i>Parameter</i>	<i>Analyte</i>	<i>Original Sample ID</i>	<i>Original Result</i>	<i>Duplicate Sample ID</i>	<i>Duplicate Result</i>	<i>RPD</i>	<i>Units</i>	<i>Qualifier ⁽¹⁾</i>
Metals	Arsenic	FRT 9A	15.8	FRT DUP1	8.86	56	mg/Kg	J
Metals	Manganese	FRT 11B	262	FRT DUP3	151	54	mg/Kg	J
TOC	TOC	FRT 9A	470	FRT DUP1	160	98	mg/Kg	J
SVOCs	Fluoranthene	FRT 9A	2830	FRT DUP1	1570	57	µg/Kg	J
SVOCs	Fluoranthene	FRT 11B	2370	FRT DUP3	870	93	µg/Kg	J
SVOCs	Phenanthrene	FRT 11B	1650	FRT DUP3	330 U	133	µg/Kg	J
SVOCs	bis(2-Ethylhexyl)phthalate	FRT 7C (2-12)	13000	FRT DUP2	7000	60	µg/Kg	J

Notes:

- (1) Qualifier is associated with both the original and duplicate sample.
- J Estimated.
- RPD Relative Percent Difference.
- SVOCs Semi-Volatile Organic Compounds.
- TOC Total Organic Carbon.

TABLE 9
QUALIFIED SAMPLE RESULTS DUE TO ANALYTE CONCENTRATIONS IN THE EQUIPMENT BLANK
SITE INVESTIGATION
GENERAL MOTORS CORPORATION
FLINT, MICHIGAN
OCTOBER - NOVEMBER 2006

<i>Parameter</i>	<i>Analysis Date</i>	<i>Analyte</i>	<i>Blank Result</i> ⁽¹⁾	<i>Sample ID</i>	<i>Sample Result</i>	<i>Qualified Sample Result</i>	<i>Units</i>
Metals	11/10/06	Silver	0.324	FRT 12C	0.13	0.13 U	mg/Kg
			0.186	FRT 12C (2-12)	0.11	0.11 U	mg/Kg
			0.184	FRT 7C (12-24)	0.31	0.31 U	mg/Kg
			0.321	FRT 9A	0.24	0.24 U	mg/Kg
			0.259	FRT DUP1	0.33	0.33 U	mg/Kg

Notes:

- (1) Blank results have been adjusted to reflect individual sample dry weights, percent solids, and preparation factors.
- U Non-detect at associated value.

Appendix C

Screening-Level Ecological Risk
Assessment for the Flint River



**Screening-Level Ecological Risk
Assessment for the Flint River at
General Motors Corporation
NAO Flint,
Flint, Michigan**

Prepared for

General Motors Corporation

Prepared by

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April 2007

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Acronyms and Abbreviations

CoPC	chemical of potential concern
CSM	conceptual site model
EPA	U.S. Environmental Protection Agency
ERA	ecological risk assessment
ESL	ecological screening level
Facility	GM NAO Flint Operations facility in Flint, Michigan
GM	General Motors Corporation
MDEQ	Michigan Department of Environmental Quality
MFO	mixed-function oxidase
NAO	GM North American Operations
NEC	no-effects concentrations
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
RCRA	Resource Conservation and Recovery Act
SLERA	screening-level ecological risk assessment
SVOC	semivolatile organic compound
TOC	total organic carbon
VOC	volatile organic compound

1 Introduction

This screening-level ecological risk assessment (SLERA) for the Flint River was conducted as part of the Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) for the General Motors Corporation (GM) North American Operations (NAO) Flint Operations facility in Flint, Michigan (the Facility). The SLERA was conducted to address U.S. Environmental Protection Agency (EPA) concerns regarding potential ecological impacts resulting from stormwater discharges from the Facility to the Flint River. The SLERA was designed to support decision-making regarding the necessity for further ecological investigation of the Flint River in the vicinity of the Facility. Background information regarding GM's Flint River sediment investigation and the agreement to conduct a SLERA is provided in the Flint River Sediment Investigation report, to which this SLERA report is appended.

1.1 Objectives and Approach

This SLERA was conducted in accordance with EPA guidance (U.S. EPA 1997). The initial elements of a SLERA are the screening-level problem formulation and the ecological effects evaluation. A screening-level exposure estimate and risk calculation was also conducted to address risk for Flint River aquatic receptors with potentially complete exposure pathways.

The objective of a SLERA is to determine whether ecological risks are negligible, or to eliminate certain contaminants and exposure pathways from further consideration in the ERA process (U.S. EPA 1997). The EPA guidance (U.S. EPA 1997) states that the conclusions of a SLERA may be:

- There is adequate information to conclude that ecological risks are negligible, and therefore, no need exists for remediation on the basis of ecological risk;
- The information is not adequate to make a decision at this point, and the ERA process will continue; or
- The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted.

If a screening assessment supports the first decision (i.e., negligible risk), the ERA process ends there, with appropriate documentation to support this decision.

The process used in this assessment included sampling of sediment in the Flint River upstream, adjacent to, and downstream of the Facility; development of a conceptual site model (CSM) for aquatic receptors in the Flint River Study Area; a comparison of sediment concentrations to ecological screening levels (ESLs) to identify constituents of potential concern (CoPCs); and comparisons of sediment concentrations to alternative screening values and background concentrations in the context of an uncertainty assessment.

1.2 SLERA Organization

The remainder of this ERA is presented in six sections. Section 2 presents the screening-level problem formulation, which describes the environmental setting, identifies the hazardous constituents, presents the CSM, and identifies the ecological exposure pathways and the assessment and measurement endpoints for the SLERA. Section 3 presents the screening-level ecological effects characterization, which discusses the ecological screening levels and describes the adverse ecological effects of the hazardous constituents of concern. Section 4 presents the screening-level exposure estimation and risk characterization, which provides the results of the screening assessment as an estimate of risk. Section 5, the uncertainty analysis, provides a discussion of the sources of uncertainty in the SLERA, including a comparison to alternative screening values and background concentrations, and identifies any data gaps. Section 6 presents the summary and conclusions. Section 7 provides the list of references cited.

2 Screening-Level Problem Formulation

This section describes the environmental setting of the Flint River in the vicinity of the Facility, the surrounding terrestrial environs, the nature and extent of contamination, habitats, and potential ecological receptors. These elements are brought together, along with consideration of potential exposure pathways, in the context of developing a conceptual site model (CSM) and the assessment and measurement endpoints for this SLERA.

2.1 Environmental Setting

The environmental setting of the Flint River Study Area, including information on tributaries and outfalls, is described in Section 1.2 of the Sediment Investigation report. The Study Area extends approximately 5.2 miles, from the C.S. Mott Lake Dam, upstream of the Facility, to the Hamilton Dam, downstream of the Facility in downtown Flint (refer to Figure 1 of the Sediment Investigation report). The Study Area comprises the following three reaches:

- Upstream of the Facility (from C.S. Mott Lake Dam to 1.9 miles downstream of this dam) (refer to Figure 2 of the Sediment Investigation)
- Adjacent to the Facility (2.6 miles) (refer to Figure 3 of the Sediment Investigation)
- Downstream of the Facility and associated storm sewer outfalls to Hamilton Dam (0.7 miles) (refer to Figure 4 of the Sediment Investigation).

The upstream reach is non-urbanized, with the riparian area consisting of a wooded stretch containing mature floodplain species, with an abundant understory and groundcover. The overall undeveloped nature of the riverbanks in this reach can be seen in the aerial photo on Figure 2 of the Sediment Investigation. Several backwaters are located on both the east and west shores along the upstream reach.

The middle, or adjacent, reach is a mix of residential, commercial, and industrial properties, including the GM Facility, bordering the river with very little terrestrial habitat (refer to Figure 3 of the Sediment Investigation). Along this stretch is the Utah Dam, which is an old, inactive concrete dam with metal doors that remain partially open.

The lower, or downstream, reach is a mix of residential and commercial properties bordering the river with very little terrestrial habitat (Figure 4 of the Sediment Investigation). Along this stretch is the Hamilton Dam which is an active dam that is used to control river levels.

Storm sewers that drain portions of the Facility also drain industrial, commercial, and residential areas outside the boundaries of the Study Area. In addition, numerous storm-sewer outfalls that are unrelated to the Facility drain into the Flint River within the Study Area. Tributary drainages and runoff from industrial, commercial, and residential properties, as well as roads and railroads in the Flint metropolitan area, contribute to the sediment and contaminant load of

the Flint River Study Area. These sources and the Flint River flow-control structures are described in more detail in Section 1.2 of the Sediment Investigation.

2.2 Identification of Hazardous Constituents

Consideration of the 2005 Michigan Department of Environmental Quality (MDEQ) data set, and the results of the 2006 Flint River Sediment Investigation were used to identify the hazardous constituents that are assessed in this SLERA.

Hazardous constituents for inclusion in the SLERA were identified based on several criteria, including 1) whether they are site-related, 2) whether they were detected, and 3) whether they are present in sediment at elevated concentrations based on the results of statistical analyses presented in Section 3.2 of the Sediment Investigation.

2.2.1 MDEQ 2005 Sediment Sampling

In April 2005, MDEQ, accompanied by EPA, conducted biased sediment sampling in the Flint River at a total of six locations upstream, adjacent to, and downstream of the Facility. The sediment samples were analyzed for inorganics, polychlorinated biphenyls (PCBs), semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). Low levels of PCBs, metals, and polycyclic aromatic hydrocarbons (PAHs) were detected. As described above, there are multiple sources of contaminants to the river. Consistent with observations in other urban watersheds, this combination of sources (both Facility-influenced sources and those unrelated to the GM Facility) would be expected to result in low-level concentrations of constituents in sediment, such as those that were seen in the MDEQ Flint River data set.

2.2.2 GM 2006 Sediment Sampling

In October 2006, ARCADIS BBL and Exponent collected sediment samples from each of three reaches of the river. Nine transects were established along the Flint River throughout the 5.2-mile Study Area. Three transects were evenly spaced along each of three reaches (i.e., upstream, adjacent, and downstream) to establish "unbiased" sampling locations, which were intended to represent areas not unduly influenced by any single discharge or group of discharges. Three additional "biased" transects were established to coincide with locations of Facility storm-sewer outfalls 003, 005, and 013. The locations of these twelve transects are illustrated on Sediment Investigation Figures 2 through 4. The individual station locations are described below. Section 1.2 of the Sediment Investigation discusses the prevalence of Facility-related and non-Facility-related outfalls throughout each Study Area reach.

Stations FRT 1, 2, and 3 are located in the upper reach of the Study Area, which is a non-urbanized, wooded stretch of the river with a few houses situated along the eastern shore (Figure 2 of the Sediment Investigation). Throughout this reach, there are five non-GM outfalls.

Stations FRT 4, 5, 6, 10, 11, and 12 are located in the middle, or adjacent, reach of the Study Area, which is a mix of residential, commercial and industrial properties along the western

shore, and mostly residential properties along the eastern shore (Figure 3 of the Sediment Investigation). Throughout this reach there are 17 GM-influenced outfalls and 27 non-GM outfalls. Station FRT 4 is the only station above the Utah Dam in this reach of the river.

Stations FRT 7, 8, and 9 are located in the lower, downstream, reach of the Study Area, which is a mix of commercial and industrial properties along the western and eastern shores (Figure 4 of the Sediment Investigation). The Hamilton Dam is at the southern end of this reach. Throughout this reach there are 18 non-GM outfalls.

A total of 21 surficial (0- to 2-inch) sediment samples were submitted for laboratory analysis. In addition, four sediment cores were collected for sediment probing and sampling. A total of 14 subsurface (>2 inches deep) samples were submitted for analysis. Samples were analyzed for SVOCs, PCBs, total organic carbon (TOC), metals, and particle size. Further details of the 2006 sampling are provided in Section 2 of the Sediment Investigation report.

Section 3.2.2 of the sediment investigation provides statistical analyses in which concentrations of constituents in surface sediment were compared between the river reaches. A total of 13 constituents showed statistically higher mean and/or median concentrations between the upstream and adjacent or downstream reaches. Thus, the following 13 constituents were retained for the SLERA:

- Benzo(a)pyrene
- Benzo(b)fluoranthene
- Benzo(g,h,i)perylene
- Benzo(k)fluoranthene
- Chrysene
- Fluoranthene
- Fluorene
- Indeno(1,2,3-cd)pyrene
- Pyrene
- Chromium
- Copper
- Lead
- Zinc

not have conc's yet

2.3 Conceptual Site Model

The preliminary CSM for the Flint River Study Area describes the plausible links between Facility-related hazardous constituents and potential ecological receptors in the Flint River. The CSM integrates and provides a framework for the information that will be used to form the basis of assessment and measurement endpoints for evaluation of ecological risk in the Flint River Study Area and traces the movement of hazardous constituents from their sources to the ecological receptors in the Flint River. The CSM, shown in Figure 1, identifies potential sources of contaminants, potentially exposed receptor communities, and the mechanisms by which contaminants may affect the exposed communities.

As illustrated in the CSM (Figure 1), potential sources of Facility-related hazardous constituents to the Flint River include stormwater runoff or discharge, historic discharges and/or spills, and groundwater discharge to the river. These sources are described in Section 1.2 of the Sediment Investigation.

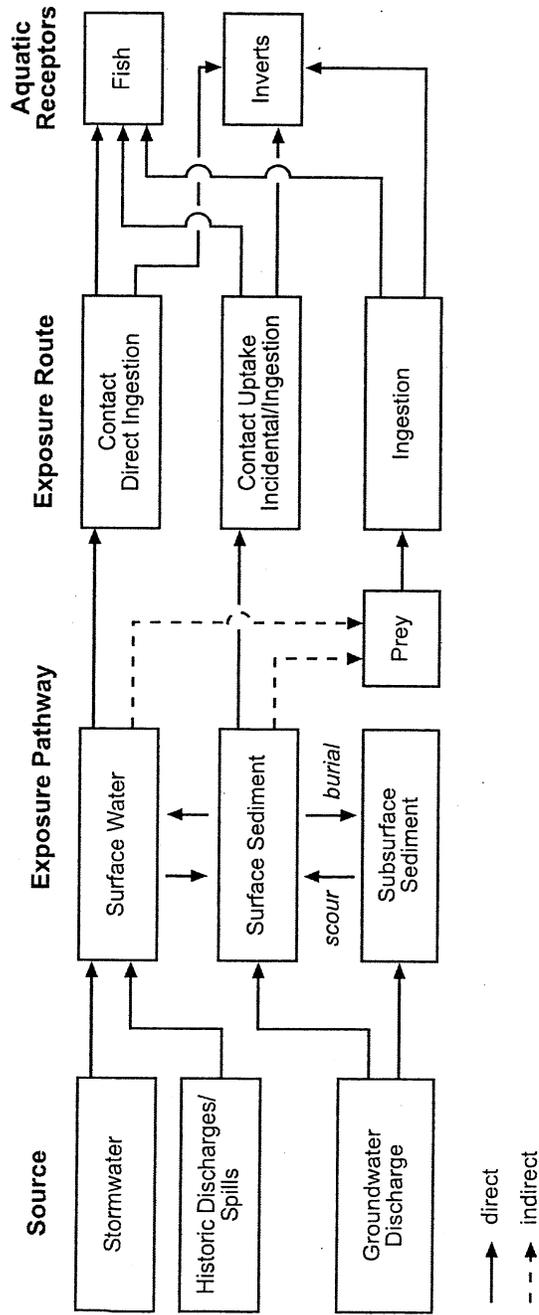


Figure 1. Conceptual site model for Flint River Study Area

nice WR 9-6 P

2.3.1 Transport and Fate

Contaminant transport and fate are functions of the physical and chemical characteristics of a contaminant, as well as the environmental media through which it has potential to be transported or transformed. This section provides an overview of potential contaminant transport and fate processes for hazardous constituents in the Flint River. Contaminant migration into surface water can occur through surface water runoff, groundwater discharge, and directly via point sources such as outfalls. In surface water, contaminants may be transformed, remain dissolved in the water column, volatilize to air, or sorb to bottom or suspended sediments.

An important chemical property that influences the transport and fate of contaminants in aquatic systems is the chemical's solubility. Constituents potentially associated with the Facility detected in the Flint River sediment include a number of relatively insoluble metals (i.e., chromium, copper, lead, and zinc) and organic chemicals (i.e., PAHs). These specific metals and PAHs have high affinity for organic matter and partition primarily onto the organic matter contained in suspended solids within the water column and sediments (Eisler 2000; Bourg 1981). In regard to the metals, other environmental factors that affect the ability of the suspended solids and sediment to bind the metals, which include the proportion of other absorbent materials such as clays and metals oxides, and the pH of the environment. More binding of these metals is expected to occur at neutral pH, and less binding will occur as the pH in the environment decreases. The transport and fate of inorganic constituents is influenced by pH, temperature, and water hardness.

The transport and fate of these insoluble constituents parallels the transport of the soil or sediment particles to which these compounds are adsorbed. Therefore, in the upland environment, the rate of erosion of soils containing these constituents and transport by overland flow to discharge points adjacent to the river is a key factor in controlling the rate of discharge of these constituents into the aquatic environment. Once introduced to the aquatic environment, these insoluble constituents (i.e., PAHs and metals), can be carried downstream on particles before settling out in depositional areas and becoming part of the sediment. The characteristics of sediment-particle transport depend on the hydrologic characteristics of the surface water body. If the discharge occurs in low-energy areas of the surface water body, deposition will likely occur near the point of discharge. If the discharge occurs in higher energy areas of the surface water body (e.g., high flow rate), the sediment may be carried downstream some distance until lower energy depositional areas are reached. In the case of PAHs, it has been reported that, in most cases, the deposition of the PAHs in sediment within the aquatic environment appears to occur near the source (Neff 1979). This would be expected to be the case for the metals too, because they behave in a manner similar to the PAHs.

Within depositional regions where sources have been curtailed, contaminants can become buried by continual deposition of clean sediment. Conversely, contaminated sediment may have the potential to become resuspended and transported downstream during high flow events or by ice scour.

The PAHs released to the environment can be degraded by a number of environmental processes. The most important environmental processes controlling the fate and degradation of

PAHs in the aquatic environment are photo-oxidation, chemical oxidation, and biological transformation by microbes and animals (Neff 1979). The low-molecular-weight PAHs (e.g., fluorene) generally are more water soluble, and thus have a higher potential for environmental degradation than the higher-molecular-weight PAHs, such as benzo(a)pyrene. This tends to be related in part to the increased bioavailability of the more water-soluble PAHs as they are released more readily into the pore water of the sediments and, thus, are more accessible to microbes. In some cases, animals and microbes can degrade the PAHs to metabolites that will ultimately be completely degraded (Eisler 2000). However, within animals, the PAHs may be bioactivated in the liver by specific enzyme systems to carcinogenic metabolites. This is the case with some of the higher-molecular-weight PAHs such as benzo(a)pyrene, which is not carcinogenic until it is bioactivated by these enzyme systems. The amount of activation and metabolism varies from species to species (Eisler 2000). Mammals tend to metabolize PAHs more efficiently than fish, and fish more efficiently than benthic invertebrates.

Of the hazardous constituents within the Flint River Study Area, metals are not able to be degraded like organic constituents and therefore will be more persistent than PAHs. As discussed above, low-molecular-weight PAHs (e.g., fluorene) generally have a high potential for environmental degradation. However, in sediments where little oxygen or light is present, the rate of PAH degradation is expected to be slow (Neff 1979).

2.3.2 Ecological Exposure Pathways

Potential exposure pathways to aquatic receptors (fish and invertebrates) in the Flint River include both direct pathways (i.e., contact with and direct ingestion of surface water and incidental ingestion of surface sediment) and indirect pathways (i.e., ingestion of contaminated prey such as benthic invertebrates). Exposure to sediment by ecological receptors is generally of concern at the surface interval (e.g., 0–2 inches). However, deeper sediment might also be exposed during extreme flow events or from ice scour. Although there is no direct exposure pathway for constituents in subsurface sediment to ecological receptors, subsurface sediment was evaluated at EPA's request, to illustrate worst-case potential ecological exposure during deep sediment mixing that might occur during a flood event or as a result of ice scour.

2.3.3 Assessment and Measurement Endpoints

An assessment endpoint is “an explicit expression of the environmental value that is to be protected,” and it should define “both the valued ecological entity at the site (e.g., a species, ecological resource, or habitat type) and a characteristic(s) of the entity to protect (e.g., reproductive success, production per unit area, areal extent)” (U.S. EPA 1997). A measurement endpoint measures the effect of a CoPC on a representative receptor to make inferences about the population or community represented by the assessment endpoint.

- Because benthic macroinvertebrates have an intimate association with sediment, and due to their importance in the aquatic food chain, the assessment endpoint selected for this SLERA is survival, growth, and reproduction of benthic macroinvertebrates.

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- The measurement endpoint used to evaluate the assessment endpoint is the chemical concentrations in Flint River sediment compared to ecological screening benchmarks for the protection of aquatic life.

3 Screening-Level Ecological Effects Characterization

The screening-level ecological effects characterization establishes conservative thresholds for adverse ecological effects, or ecological screening levels. These screening levels are used in the screening-level exposure and risk characterization (Section 4) to identify the ecological CoPCs. This section also provides toxicity profiles that describe what is known about the ecological effects of the hazardous constituents.

3.1 Ecological Screening Levels

Chemical constituents in sediment are screened to identify CoPCs to ecological receptors. This is accomplished in Section 4 by comparing chemical concentrations in sediment to available and appropriate ecological risk-based screening criteria. The criteria used for this screening are the U.S. EPA Region 5 (2003) RCRA Ecological Screening Levels (ESLs). According to EPA,¹ the ESLs are initial screening levels to use in ecological risk assessments, and they are not intended to serve as cleanup levels. Screening using conservative screening values such as ESLs is intended to identify CoPCs, and to eliminate constituents that pose negligible risk from further evaluation in the ecological risk assessment process.

3.2 Adverse Effects of PAHs

PAHs are formed during incomplete combustion of fossil fuels and other organic substances. Sources of PAHs to the aquatic environment include municipal runoff, atmospheric deposition of combustion products, oil spills and petroleum industrial operations, and natural oil seeps (e.g., NRC 1985).

Toxicological effects of SVOCs, including PAHs, are highly variable. PAHs consist of hydrogen and carbon arranged in the form of two or more fused benzene rings. PAH compounds differ in the number and position of aromatic rings and in the position of substituents on the basic ring system. Unsubstituted two- or three-ring (lower molecular weight) PAHs such as naphthalene, fluorene, phenanthrene, and anthracene can be acutely toxic to aquatic organisms, but are noncarcinogenic. Four- to seven-ring (higher molecular weight) PAHs, such as chrysene and benzo(a)pyrene are significantly less toxic, but can be carcinogenic, mutagenic, or teratogenic to a variety of organisms, including fish. The lighter PAHs are generally available for microbial degradation in sediment, and the heavier PAHs are not (API 2000).

Accumulation of PAHs is largely related to an organisms' ability to metabolize the compounds. The ability to biotransform PAHs is due to the cytochrome P-450 mixed-function oxidase (MFO) system in living organisms. The MFO system is well developed in many birds, mammals, and fish and allows PAHs to be readily metabolized (Kalf et al. 1995). Therefore, direct toxicity to these receptors is unlikely at most environmental concentrations. In addition,

¹ <http://www.epa.gov/reg5rcra/ca/edql.htm>

PAHs show little tendency to biomagnify in food chains, primarily because of this rapid metabolism. Controlled studies of aquatic food chains have shown that tissue concentrations of PAHs decrease with an increase in trophic level (Broman et al. 1990). Therefore, PAHs are not passed along in the food chain, and do not accumulate to appreciable levels in predatory fish and birds. However, direct toxicity may result from metabolism (Suedel et al. 1994; U.S. EPA 1991). Chronic dietary exposure to PAHs can cause adverse effects in birds and mammals, including body-weight loss, liver damage, cancer, reproductive failure, and developmental defects (Eisler 1987, 1988).

In aquatic food chains, fish have the best capacity to metabolize PAHs, crustaceans are intermediate, and molluscs have the poorest metabolic capacity (James 1989; Stegeman and Lech 1991). Even in highly contaminated areas, only low to moderate PAH concentrations are typically found in fish (Dawe 1990; Varanasi et al. 1990). However, species at lower trophic levels with less developed MFO systems, such as benthic invertebrates, can accumulate PAHs in their tissues.

PAH metabolism varies with species and compounds. Amphipods have the ability to metabolize benzo(a)pyrene to intermediate compounds (Reichert et al. 1985). Tests with chironomids (*C. riparius*) demonstrated that benzo(a)pyrene is rapidly and completely transformed (Giesy et al. 1983). English sole (*Parophrys vetulus*) collected from polluted sites in Puget Sound, Washington, were found to contain metabolites of fluorene, dibenzofuran, phenanthrene, fluoranthene, pyrene, and benzo(a)pyrene (Krahn et al. 1987). Benzo(a)pyrene, fluoranthene, and benzo[a]anthracene were metabolized in the fish species *Pimephales promelas*, *Poecilisa reticulata*, and *Brachydanio rerio*, but naphthalene, anthracene, and phenanthrene were not (Kalf et al. 1995).

The metabolites of PAHs include intermediates that can bind covalently to DNA, RNA, and proteins and become toxic, mutagenic, or carcinogenic. Metabolites include PAH diols, phenols, quinone, and PAH conjugates with sulfate, monosaccharide, glucuronate, and glutathione (Neff 1978). The toxicity of PAHs varies, because PAHs and their metabolites exhibit different toxicodynamics. In some cases, the polar metabolites of PAHs are excreted more slowly than the parent compound (Kalf et al. 1995). For example, the metabolite of benzo(a)pyrene, 7,8-diolepoxide, has a higher carcinogenic capacity than its parent (Kalf et al. 1995).

Several studies have demonstrated adverse effects of PAH in water, especially benzo[a]pyrene, on hatching, larval development, and viability, primarily with fish, but also with invertebrates in a few cases. Typical reproductive effects noted in fish were delayed or decreased hatching (Hose et al. 1981, 1982; Winkler et al. 1983; Hall and Oris 1991), increased incidence of larval malformations (Hose et al. 1981, 1982; Hannah et al. 1982; Winkler et al. 1983), cell and tissue lesions in yolk sac fry (Hose et al. 1984), or reduced larval growth (Hannah et al. 1982). In general, effects are seen only at very high, environmentally unrealistic concentrations. For example, Hall and Oris (1991) found reductions in the number of eggs in fish exposed to anthracene at 6 $\mu\text{g/L}$ for 6 weeks, and a lowering of hatching success at 12 $\mu\text{g/L}$. However, Hose et al. (1982, 1984) found effects in fish at concentrations as low as 0.1 $\mu\text{g/L}$.

Adverse effects of PAHs on benthic invertebrates include inhibited reproduction, delayed emergence, sediment avoidance, and mortality (Eisler 1987). In fish, threshold concentrations of PAHs in sediment associated with effects in English sole range from 54 $\mu\text{g}/\text{kg}$ dry weight, for liver neoplasms, to about 2,800 $\mu\text{g}/\text{kg}$ for hepatic preneoplastic foci of cellular alteration (Johnson 2000). Based on these data, the National Marine Fisheries Service suggests a sediment quality guideline of 1,000 $\mu\text{g}/\text{kg}$ for total PAHs to protect estuarine fish from adverse effects. This guideline and the ESLs for individual PAH compounds are lower than PAH concentrations typically found in urban areas as a result of stormwater runoff and atmospheric deposition. This will be discussed in the Uncertainty Analysis, Section 5.

3.3 Adverse Effects of Metals

Organisms have evolved homeostatic mechanisms that regulate the uptake and excretion of metals to maintain tissue concentrations within desirable ranges, as well as to prevent toxic effects (Kapustka et al. 2003). For certain elements and organisms, bioaccumulation is required to maintain the organism's health and normal function; this is the case for essential trace elements such as copper and zinc. In other situations, bioaccumulation of metals produces residues that cause direct toxicity (e.g., copper toxicity to aquatic organisms) or indirect toxicity to consumers (as in selenium accumulation by plants). To further complicate understanding the bioaccumulation and metabolism of metals, the metabolism of an essential element can affect the metabolism of a non-essential toxic metal, as in the case of calcium and lead in the central nervous system (Kern et al. 2000). Nonessential metals, such as arsenic and lead, are not required for biological processes and are therefore not naturally regulated by the body. These metals cause toxicity at various exposure levels.

In aquatic systems, the toxic effects of metals can range from reductions in growth to mortality. Water hardness affects the degree of toxicity of cadmium, chromium, copper, lead, nickel, silver, and zinc, with toxicity decreasing with increasing water hardness. The aquatic organisms that are most sensitive to the effects of exposure to metals are early life stages of benthic organisms and fish.

EPA Region 5 provides toxicity profiles for inorganic constituents on their ecological risk assessment website (<http://www.epa.gov/R5Super/ecology/html/toxprofiles.htm>). The information from these profiles for the inorganic constituents of concern—chromium, copper, lead, and zinc—is summarized below and supplemented with information on these constituents from the available ATSDR toxicological profiles.

3.3.1 Chromium

Chromium exists in two oxidation states in the environment: trivalent ($+3$) and hexavalent ($+6$). The more toxic hexavalent chromium is readily converted to trivalent chromium in animals; this appears to protect higher organisms from adverse effects of low-level exposures to chromium. Lower-trophic-level organisms, however, are generally more susceptible to the toxic effects of chromium. Aquatic ecological impacts from chromium result from direct exposure of benthic invertebrates and early life stages of freshwater fish. Chromium bioaccumulates in algae and

other aquatic vegetation, and also in aquatic invertebrates. However, it does not biomagnify in aquatic food webs. The ecological effects of chromium include inhibited growth in aquatic plants (e.g., duckweed and algae), reduced fecundity and survival of benthic invertebrates, and reduced growth of freshwater fish. Chromium is a known carcinogen, mutagen, and teratogen.

The most significant anthropogenic sources of chromium in surface water and groundwater are wastewaters from electroplating operations, leather tanning industries, residential treatment plants, textile manufacturing, and deposition of airborne chromium. In a 1972 survey, the contribution of different sources to chromium load in the influent wastewater of a treatment plant in New York City was estimated to be as follows: electroplating industry, 43%; residential wastewater, 28%; other industries, 9%; runoff, 9%; and unknown, 11% (Klein et al. 1974, as cited in ATSDR 2000). On a worldwide basis, the major chromium source in aquatic ecosystems is domestic wastewater effluents (32.2% of the total). Atmospheric fallout also contributes about 6.4% (Nriagu and Pacyna 1988, as cited in ATSDR 2000).

Significant sources of chromium released into soil include disposal of commercial products that contain chromium (51%), disposal of coal fly ash and bottom fly ash from electric utilities and other industries (33.1%), agricultural and food wastes (5.3%), animal wastes (3.9%), and atmospheric fallout (2.4%) (Nriagu and Pacyna 1988, as cited in ATSDR 2000).

The chromium level in soils varies greatly and depends on the composition of the parent rock from which the soils were formed. Basalt and serpentine soils, ultramafic rocks, and phosphorites may contain chromium as high as a few thousand mg/kg (Merian 1984, as cited in ATSDR 2000), whereas soils derived from granite or sandstone will have lower concentrations of chromium (Swaine and Mitchell 1960, as cited in ATSDR 2000). The concentration range of chromium in 1,319 samples of soils and other surficial materials collected in the conterminous United States was 1–2,000 mg/kg, with a geometric mean of 37 mg/kg (USGS 1984).

3.3.2 Copper

Copper is an essential micronutrient, and bioaccumulates in both fish and mollusks; however, it can be toxic at higher levels. Copper can be highly toxic in aquatic environments and has demonstrated adverse effects in both fish and invertebrates. Copper is also an algacide, with single-cell and filamentous algae, and cyanobacteria being particularly susceptible to acute effects at low concentrations. Copper adsorbs strongly to organic matter, carbonates, and clay in sediment, thereby reducing its bioavailability.

Copper is a natural constituent of soil and can be transported into streams and waterways in runoff, either due to natural weathering or anthropogenic soil disturbances. Copper in runoff that is obtained from the natural weathering of soil or is released from disturbed soils contributes 68% of the copper released to waterways (Georgopoulos et al. 2001, as cited in ATSDR 2004). Other sources of copper include urban runoff and the use of copper sulfate. In the absence of specific industrial sources, urban stormwater runoff is the major factor contributing to elevated copper levels in river water (Nolte 1988, as cited in ATSDR 2004). Copper in stormwater runoff originates from the sides and roofs of buildings, various emissions (such as from automobiles), and wet and dry depositional processes (Davis et al. 2001, as cited in ATSDR 2004). Stormwater runoff normally contributes approximately 2% to the total

copper released to waterways. Concentrations of between 1 and 100 $\mu\text{g/L}$ of copper in stormwater runoff have been measured (Georgopoulos et al. 2001, as cited in ATSDR 2004).

An estimated 97% of copper released from all sources into the environment is released to land, primarily in the form of tailings and overburdens from copper mines and tailings from mills (Perwak et al. 1980, as cited in ATSDR 2004). Other releases to land include sludge from publicly owned treatment works, municipal refuse, waste from electroplating, iron and steel producers, and discarded copper products (e.g., plumbing, wiring) that are not recycled. Sludge from sewage treatment plants is a major source of copper released to land (Nriagu and Pacyna 1988, as cited in ATSDR 2004). In addition, agricultural products are believed to constitute 2% of the copper released to soil (Perwak et al. 1980, as cited in ATSDR 2004).

3.3.3 Lead

In the aquatic environment, lead partitions primarily to sediments, but can become mobile and thus more bioavailable under conditions of low pH, hardness, and organic matter content. Lead bioaccumulates in aquatic plants and benthic organisms, but does not biomagnify in aquatic food webs. Lead is a known carcinogen and can also adversely affect reproduction, liver and thyroid function, and disease resistance. Lead has shown adverse effects in algae, invertebrates, and fish. Fish exposed to high concentrations of lead have demonstrated a wide range of effects, including muscular and neurological degeneration, growth inhibition, mortality, reproductive effects, and paralysis. Lead also can adversely affect invertebrate reproduction and algal growth.

Of the known aquatic releases of lead, the largest ones are from the steel and iron industries, and lead production and processing operations (U.S. EPA 1982, as cited in ATSDR 2005a). Urban runoff and atmospheric deposition are also significant indirect sources of lead found in the aquatic environment. Lead reaching surface waters is sorbed to suspended solids and sediments (U.S. EPA 1982). Lead is also released into surface water from the use of lead shot and lead sinkers. In 1991, the U.S. Fish and Wildlife Service banned the use of lead shot when hunting waterfowl, such as geese or ducks, to avoid releasing lead directly to surface water.

While the majority of lead releases are to land, they constitute much lower exposure risks than releases to air and water. Metal mining, coal mining, electrical utilities, and hazardous waste facilities' solvent recovery facilities are the industrial sectors that contribute most heavily to releases of lead to land. Most of the lead released to land, however, becomes tightly bound and immobile.

3.3.4 Zinc

Anthropogenic sources of zinc come from discharges from smelters, mine tailings, coal and bottom fly ash, and the use of commercial products such as fertilizers and wood preservatives that contain zinc (ATSDR 2005b). In aquatic systems, zinc primarily partitions to sediment and less frequently exists in dissolved form as hydrated zinc ions and organic and inorganic complexes. Zinc is an essential nutrient, but at high concentrations, exhibits adverse effects on growth, survival, and reproduction. Zinc bioaccumulates moderately in aquatic organisms, and

bioconcentration rates are higher in crustaceans and bivalves than in fish. However, biota contain relatively little zinc compared to sediments (ATSDR 2005b).

Zinc and its compounds are found in the earth's crust and are present in most rocks, certain minerals, and some carbonate sediments. As a result of weathering of these materials, soluble compounds of zinc are formed and may be released to water (NAS 1977, as cited in ATSDR 2005b). The largest input of zinc to water results from erosion of soil particles containing natural traces of zinc (45,400 metric tons/year) (U.S. EPA 1980, as cited in ATSDR 2005b). Urban runoff, mine drainage, and municipal and industrial effluents are smaller but more concentrated sources of zinc in water. Davis et al. (2001) estimated the zinc loadings in urban stormwater runoff. In this study, buildings and automobiles were found to contribute 95% of loadings (0.646 kg/ha/year) to stormwater runoff in urban environments.

Limited information is available on total releases of zinc to soil. Zinc is often present in soils and grasses as a result of atmospheric deposition. Furthermore, approximately 22,000 tons (20,000 metric tons) of zinc is used in fertilizers each year in the United States (NAS 1977, as cited in ATSDR 2005b). Municipal sludges applied to cropland soils can also be an important source of trace metals, including zinc (Chang et al. 1987, as cited in ATSDR 2005b). The four most important sources of zinc in soil were estimated to be smelter slugs and wastes, mine tailings, coal and bottom fly ash, and the discharge of commercial products such as fertilizers (Nriagu and Pacyna 1988, as cited in ATSDR 2005b).

4 Screening-Level Exposure and Risk Characterization

The screening-level risk characterization includes the results of the sediment screening, identifies the CoPCs, and provides input, along with the uncertainty analysis (Section 5), for making a decision regarding whether or not risks are negligible for aquatic ecological receptors in the Flint River Study Area.

4.1 Results of Screening Assessment

The 13 hazardous constituents that were identified in Section 2.2 were evaluated in the screening assessment. Of these constituents, chemicals that are present in sediment at concentrations that exceed the ESLs, and chemicals for which no screening values are available, were identified as CoPCs. Constituents that did not exceed the ESLs in any sample were eliminated from further consideration in the ecological risk assessment process. In the screening assessment, duplicate samples were averaged using one-half the detection limit for non-detects. The results of the screening are summarized below for the biased and unbiased surface and subsurface sediment samples.

4.1.1 Unbiased Surface Samples

Table 1 provides the screening of surface sediment for the unbiased sampling transects. PAHs were not detected in the upstream samples. PAHs and metals were found at higher concentrations in the samples from the adjacent and downstream reaches, compared to the upstream reach. This trend in concentrations would be expected based on the prevalence of outfalls and the urbanized nature of the watershed in the adjacent and downstream reaches (refer to Section 3.2 and Figures 5 through 30 of the Sediment Investigation report).

No detected chemicals exceeded ESLs for unbiased surface samples in the upstream reach.

In the adjacent reach, all of the PAHs except benzo(b)fluoranthene exceeded ESLs. Station FRT 4C exhibited the highest concentrations of these PAHs; however, all except fluoranthene were less than 1 part per million (ppm). Lead at station FRT 5A is the only inorganic constituent that exceeded its ESL in the adjacent reach. Mean concentrations of six PAHs and lead exceeded ESLs in this reach.

In the downstream reach, all of the PAHs except benzo(b)fluoranthene exceeded ESLs. Copper, lead, and zinc also exceeded ESLs. Station FRT 9A had the highest detected concentrations of PAHs and metals. This sample also had the highest concentration of TOC and the highest proportion of clay of all unbiased samples. Most other stations (in all reaches) had very low TOC and were predominantly sand. Mean concentrations of eight PAHs, lead, and zinc exceeded ESLs in the downstream reach.

Benzo(b)fluoranthene and chromium were eliminated from further consideration in the ecological risk assessment process for the unbiased surface sediment, because these chemicals did not exceed ESLs in any sample within this data set.

4.1.2 Biased Surface Samples

Table 2 provides the screening of surface sediment for the sampling transects that were biased to the Facility-influenced outfalls (003, 005, and 013). As with the unbiased surface samples, all PAHs except benzo(b)fluoranthene, as well as copper, lead, and zinc, exceeded ESLs. The highest concentrations of PAHs were found at station FRT 11B. Metals exceeded ESLs only at station FRT 12C. This station had the highest clay content and TOC of all biased surface samples. Mean concentrations of eight PAHs exceeded ESLs for this data set.

Benzo(b)fluoranthene and chromium were the only constituents of the 13 chemicals identified for the SLERA that were eliminated from further consideration in the ecological risk assessment process for the biased surface sediment data set.

4.1.3 Unbiased Subsurface Samples

Table 3 provides the screening of subsurface sediment for the unbiased sampling transects. As with the surface samples, PAHs were not detected in the upstream samples, and PAHs and metals were found at higher concentrations in the samples from the adjacent and downstream reaches, compared to the upstream reach. Clay and silt content, and TOC, were higher in the subsurface samples from the downstream reach compared to the other reaches.

In the upstream or adjacent reaches, no detected chemicals in subsurface sediment exceeded ESLs. In the adjacent reach, one low estimated concentration of benzo(a)pyrene (station FRT 4A) exceeded the ESL for this chemical.

In the downstream reach, all PAHs except benzo(b)fluoranthene, as well as chromium, copper, lead, and zinc, exceeded ESLs. PAHs were detected at the highest concentrations in the 12- to 24-inch interval at station FRT 7C. Metals were also detected at elevated concentrations in this sample, as well as in the shallower interval (2–12 inches) for this station. TOC was also higher at these intervals than in the other subsurface unbiased samples. Mean concentrations for eight PAHs and the four metals exceeded ESLs in the downstream reach.

Benzo(b)fluoranthene was the only chemical that was eliminated from further consideration in the ecological risk assessment process for the unbiased subsurface sediment data set, because this chemical did not exceed the ESL in any sample.

4.1.4 Biased Subsurface Samples

Table 4 provides the screening of subsurface sediment samples that were biased to the Facility-influenced outfalls. All PAHs except benzo(b)fluoranthene, as well as copper, lead, and zinc, exceeded ESLs. The highest concentrations of chemicals were found at station FRT 12C in the 2- to 12-inch depth interval. Metals exceeded ESLs in this sample only. This station had the

highest silt/clay content and TOC of all biased subsurface sediment samples. Mean concentrations of eight PAHs exceeded ESLs for this data set.

Benzo(b)fluoranthene and chromium did not exceed ESLs in any biased subsurface sample, and therefore, were eliminated from further consideration in the ecological risk assessment process for this data set.

4.2 Screening-Level Risk Characterization

The screening-level risk characterization is conducted to “ensure that potential ecological threats are not overlooked” (U.S. EPA 1997). In addition, contaminants that are identified as negligible risk are eliminated from consideration in the ecological risk assessment process.

Based on the screening vs. ESLs, the following chemicals were identified as ecological CoPCs for Flint River sediment:

- **Surface Sediment:** Benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, pyrene, copper, lead, and zinc were identified as the CoPCs for unbiased samples in the adjacent and downstream reaches, as well as for the biased surface sediment samples (adjacent reach). Benzo(b)fluoranthene and chromium were eliminated from further consideration in the ecological risk assessment process for all surface sediment.
- **Subsurface Sediment:** Benzo(a)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, pyrene, chromium, copper, lead, and zinc were identified as the CoPCs for the unbiased subsurface sediment in the downstream reach. These same chemicals, with the exception of chromium, were identified as the CoPCs for the biased subsurface sediment (adjacent reach). Benzo(b)fluoranthene was eliminated from further consideration in the ecological risk assessment process for all subsurface sediment, and chromium was eliminated from the biased (adjacent) subsurface data set.

According to U.S. EPA (1997), screening ecotoxicity assessments are conducted to avoid underestimating risk. Uncertainties associated with the screening process are taken into consideration in the next section to allow conclusions to be made regarding ecological risk from exposure to the sediment CoPCs.

5 Uncertainty Analysis

Analyses of scientific data for risk assessment purposes depend on professional judgment. Professional judgment is needed to draw conclusions regarding ecological risk, and specifically to determine the relevance of available data, develop assumptions to fill data gaps, and to interpret the ecological significance of predicted effects (U.S. EPA 1992). Therefore, this SLERA includes an uncertainty analysis.

Uncertainty in ecological risk assessment is due, in part, to natural variability, and therefore, many uncertainties are due to the limits of scientific knowledge about the responses of ecological receptors to environmental contaminants. Uncertainty is also due to the assumptions used in the ecological risk assessment process. Uncertainty can result in either an over- or under-estimation of risk. Conclusions regarding ecological risk must take into account the factors contributing to this uncertainty. The sources of uncertainty and their potential influence on conclusions regarding risk are summarized in this section. Uncertainty in this SLERA is associated with the sampling data and the screening values, as well as with data gaps, as discussed below.

One source of uncertainty is the selection of CoPCs based on the sampling data and available toxicity information (e.g., ESLs). Additional uncertainties result from the exposure assessment, as a consequence of the uncertainty due to the heterogeneity of the chemical monitoring data. Other uncertainties pertain to the bioavailability and bioaccessibility of the CoPCs and the distribution of ecological receptors. In addition, the SLERA does not account for simultaneous exposures to multiple substances in the screening stages of the assessment. Each of these sources of uncertainty may result in either an over- or underestimation of risk.

5.1 Uncertainties Associated with Ecological Screening Levels

A major source of uncertainty for the SLERA is associated with the use of conservative screening levels (i.e., ESLs). ESLs, as with all screening benchmarks, are intended to be conservative, such that a risk assessor or risk manager has a high level of confidence that a reported concentration of a CoPC that is below a screening value does not pose an unacceptable ecological risk. Conversely, an exceedance of a screening benchmark does not necessarily indicate an unacceptable ecological risk; rather, only that additional evaluation is needed. This uncertainty analysis provides the additional evaluation needed to appropriately interpret the exceedances of ESLs noted in Section 4.

Screening-level benchmarks, including ESLs, are significant sources of uncertainty in ERAs for the following reasons:

- Test conditions on which some of the ESLs are based most likely do not mimic natural exposure and may overestimate bioavailability
- Relative sensitivity of the receptor compared to the test species is likely unknown

- Identification of no-effect thresholds is imprecise and dependent on selected dose intervals
- Chronic no-effect thresholds have not been measured for many hazardous constituents and may have been estimated from low-effect thresholds or acute exposure studies
- Uncertainty factors that are often applied in calculating some screening benchmarks are generalized and ignore species-specific sensitivities
- In many cases, screening values are lower than detection limits and often lower than background concentrations.

The analytical data for the Flint River sediment were compared to Region 5 sediment ESLs. The toxicological basis of these screening values is variable, and as mentioned above, many of the screening values are lower than detection limits. The conservative nature of these screening values may result in an over-prediction of risk.

5.2 Consideration of Alternate Screening Values and Regional Background Concentrations

As an aid to interpreting the potential ecological significance of the exceedances of ESLs, the Flint River sediment data were compared to sediment no-effects concentrations (NECs) (Tables 5 through 8), and to regional and urban background values (Tables 9 through 12). This analysis was conducted only for the CoPCs, or those analytes that exceeded the ESLs in the Screening-Level Exposure and Risk Characterization (Section 4). The NECs, reported by Ingersoll et al. (1996), were derived from freshwater sediment toxicity tests on amphipods and represent threshold values below which adverse effects to benthic organisms would not be expected.

The background values that were used in this analysis were the typical urban background concentrations for PAHs that were compiled by ATSDR (1995), and the MDEQ (1999) Statewide reference sediment chemistry for selected metals. The ATSDR values are the background urban soil concentrations that were derived from a variety of sources for individual PAHs. Appropriate urban background PAH concentrations for sediment would be preferable to soil data, but are not available. Soil PAH compiled by ATSDR (1995) are deemed to be a suitable surrogate for sediment data in this case, because sediment in Study Area reaches of the Flint River are expected to be of local terrigenous origin. The MDEQ values for inorganics were derived from sediment samples collected in 1994, 1997, and 1998 from reference rivers and streams in Michigan where the biological communities were categorized as excellent.

To provide an additional perspective, the mean concentrations of metals in soils from an urban watershed in southeastern Michigan (the Rouge River watershed; Murray et al. 2004) were also added to the background comparison tables.

5.2.1 Results for Alternate Screening Values

NECs, reported by Ingersoll et al. (1996), were developed for sensitive and representative freshwater benthic species. Several features of the NEC derivation process make NECs useful as toxicity benchmarks for secondary screening purposes. NECs were developed from empirical toxicity data, as opposed to predicted concentrations. Finally, an NEC is the sediment concentration of a given chemical above which a statistically significant effect is observed, and thus represents a more realistic effects level than the conservative sediment screening benchmarks used in ESLs.

The results of the comparisons to the NECs as alternate screening values, which are more likely to have a relevant toxicological basis than ESLs, are presented below. As can be seen from Tables 5 through 8, NEC exceedances were infrequent and often associated with individual samples, suggesting that any adverse effects to benthic organisms would be spatially limited within the Flint River Study Area.

5.2.1.1 Surface Samples

Table 5 compares the data for CoPCs identified in unbiased surface sediment to the NECs. Only lead at station FRT 5A exceeded the NEC in the adjacent reach. In the downstream reach, two PAHs exceeded their NECs at stations FRT 9A and B for benzo(a)pyrene, and at station FRT 9A for indeno(1,2,3-cd)pyrene. These exceedances were slight (i.e., less than a factor of two), and the mean concentrations of these PAHs for the downstream reach did not exceed the NECs.

Table 6 compares the data for CoPCs identified in surface sediment samples that are biased to the GM outfalls to the NECs. No CoPCs in biased samples exceeded NECs.

Mean concentrations of CoPCs did not exceed the NEC values in the adjacent or downstream reaches for the unbiased data set, and no chemicals exceeded NECs in the biased surface sediment samples. This suggests that any potential effects (as predicted by the exceedance of an NEC) would be spatially limited.

5.2.1.2 Subsurface Samples

Table 7 compares the data for CoPCs identified in unbiased subsurface sediment to the NECs. No unbiased subsurface samples exceeded NECs in the reach adjacent to the Facility. Chromium and lead exceeded NECs in the subsurface sample FRT 7C at the 2- to 12-inch interval, and five PAHs and lead exceeded NECs at the 12- to 24-inch interval. Mean concentrations across all subsurface depths (2–46 inches) exceeded NECs for benzo(a)pyrene and indeno(1,2,3-cd)pyrene. With the exception of benzo(a)pyrene (7 times the NEC) and benzo(g,h,i)perylene (2.5 times the NEC) in the 12- to 24-inch sample from FRT 7C, all exceedances were within a factor of 2 of the NEC value.

Table 8 compares the biased subsurface samples to NECs. Three PAHs—benzo(a)pyrene, benzo(g,h,i)perylene, and indeno(1,2,3-cd)pyrene—exceeded NECs in the 2- to 12 inch interval, all by less than a factor of two.

NEC exceedances in the subsurface samples were limited to two samples (FRT 7C and FRT 12C), and in the 2- to 24inch interval.

5.2.2 Results for Regional and Urban Background Screening

Samples where CoPCs were identified in the initial screening (comparison to ESLs) were also compared to regional reference-site background values for inorganics and typical urban concentrations for inorganics and PAHs to provide an additional perspective by which to interpret the ecological significance of the ESL exceedances. The background values that were used in this analysis were the typical urban background soil concentrations for PAHs, reported by the ATSDR (1995); statewide reference sediment chemistry for all ecological regions, reported by the MDEQ (1999); and the mean concentrations of metals in Michigan surface soils for residential, commercial, and industrial land uses in an urban watershed (Murray et al. 2004).

5.2.2.1 Surface Samples

Table 9 presents the results of the comparison of unbiased surface samples to regional and urban background concentrations. An estimated concentration of benzo(a)pyrene (at station FRT 4C) and a detected concentration for lead (at FRT 5A) exceeded the urban background concentrations. Copper concentrations exceeded the regional background concentrations for reference rivers at stations FRT 4C and 5A. Lead also exceeded the regional reference site background value at station FRT 5A.

The mean concentration for benzo(a)pyrene exceeded the urban background value for unbiased surface samples in the adjacent reach. However, the exceedance was slight and based on an estimated detection. The mean concentration of lead exceeded the regional reference-site values, but was within the range of reported urban background concentrations for southeast Michigan.

In the downstream reach, benzo(a)pyrene, chrysene, copper, lead, and zinc exceeded background levels in unbiased surface sediment samples. Only zinc at stations FRT 9A and B exceeded the urban watershed values for inorganics in southeast Michigan, and the mean concentrations of the other inorganics (copper and lead) only slightly exceeded the reference-site background values.

Table 10 presents the background screening for surface samples collected at stations that were biased to the GM-influenced outfalls. Benzo(a)pyrene, chrysene, copper, lead, and zinc exceeded background levels in the biased surface sediment samples. Only zinc at station FRT 12C exceeded the urban watershed value, and the mean concentrations of the inorganics did not exceed any of the background levels. The mean concentration of benzo(a)pyrene exceeded the urban background level for this constituent, but only by a factor of 2 to 3.

5.2.2.2 Subsurface Samples

Table 11 presents the background screening for unbiased subsurface samples. Benzo(a)pyrene, chrysene, chromium, copper, lead, and zinc exceeded background levels in the downstream

samples. Across all depth intervals, mean concentrations of benzo(a)pyrene, chrysene, copper, lead, and zinc exceeded the urban background levels, albeit by small margins.

Table 12 presents the background screening for subsurface samples collected at stations that were biased to the GM-influenced outfalls. Benzo(a)pyrene, chrysene, copper, lead, and zinc exceeded background levels in the biased subsurface sediment samples. No metals exceeded the urban watershed values, and the mean concentrations of the inorganics did not exceed any of the background levels. The mean concentrations of benzo(a)pyrene and chrysene across all depth intervals exceeded the range of urban background levels for these constituents, also by a small margin.

6 Summary and Conclusions

This SLERA was performed to develop the information necessary to support a risk management decision regarding potential releases from the NAO Flint Facility. This section summarizes the results of the risk characterization and uncertainty analysis, and assesses the ecological significance of these results. These elements are brought together with the statistical and trends analyses conducted in the Sediment Investigation (Section 3.2 of Sediment Investigation report) as the weight of evidence to draw conclusions regarding ecological risk.

The objective of the SLERA was to determine whether ecological risks are negligible, or to eliminate certain contaminants and exposure pathways from further consideration in the ERA process. According to the U.S. EPA (1997) guidance, the conclusions of a SLERA may be:

- There is adequate information to conclude that ecological risks are negligible, and therefore, no need exists for remediation on the basis of ecological risk;
- The information is not adequate to make a decision at this point, and the ERA process will continue; or
- The information indicates a potential for adverse ecological effects, and a more thorough assessment is warranted.

The process for the Flint River SLERA can be summarized as follows: the 13 constituents identified in the Sediment Investigation were screened against conservative screening values (i.e., ESLs) to identify ecological CoPCs, concentrations of CoPCs were compared to alternative toxicology-based screening values (i.e., NECs) and background levels as part of the uncertainty analysis, to provide additional lines of evidence from which to draw conclusions regarding ecological risk. The results for each of these lines of evidence are summarized in Tables 13 and 14 for surface sediment and subsurface sediment, respectively. If a constituent and an exposure area (i.e., upstream, adjacent, or downstream reach) were eliminated in the early stages of the screening process, they are not included in Tables 13 and 14. For example, no upstream sediment concentrations for any constituent exceeded ESLs; therefore, the upstream exposure area was not evaluated in the secondary screening or background comparisons. Similarly, the ESL for benzo(b)fluoranthene was not exceeded in any sample; therefore, this constituent was eliminated from further evaluation in the SLERA.

Table 13 summarizes the weight of evidence regarding ecological risk from exposure to both unbiased and biased sets of surface sediment samples. The CoPCs in surface sediment include eight PAHs, and copper, lead, and zinc. These chemicals were compared to the NECs, which were derived by Ingersoll et al. (1996) from freshwater sediment toxicity tests on amphipods and represent threshold values below which adverse effects to sensitive benthic organisms would not be expected. Only copper in the adjacent reach and two PAHs (benzo(a)pyrene and indeno(1,2,3-cd)pyrene) in the downstream reach exceeded NECs for surface sediment. The NEC exceedances for these CoPCs were small (less than a factor of 2) and were limited to three stations, FRT 5A in the adjacent reach for lead, and FRT 9A and B in the downstream reach for

PAHs. Stations FRT 9A and B are the farthest downstream stations, and are located immediately downstream of five non-GM outfalls. In the background screening, the exceedances were again small for the surface sediments (generally within a factor of 2 or 3).

There is no direct exposure pathway for constituents in subsurface sediment to ecological receptors, and therefore, these sediments do not pose a meaningful present risk. However, subsurface sediments were evaluated at EPA's request to illustrate worst-case potential ecological exposure during deep sediment mixing that might occur during a flood event or as a result of ice scour. Table 14 summarizes the weight of evidence regarding ecological risk from exposure to both unbiased and biased subsurface sediment. The CoPCs in subsurface sediment include eight PAHs, chromium, copper, lead, and zinc. These chemicals were also compared to the NECs. Three PAHs in the adjacent reach, and five PAHs, chromium, and lead in the downstream reach, exceeded NECs for subsurface sediment. Mean concentrations of benzo(a)pyrene and indeno(1,2,3-cd) pyrene exceeded the NECs in the downstream reach for unbiased samples; however, these exceedances were small, within a factor of 2. NEC exceedances for metals in the subsurface were also small (less than a factor of 2), and were limited to downstream station FRT 7C. In the background screening, the exceedances were within a factor of 2 or 3 for the metals and were somewhat larger for the PAHs benzo(a)pyrene and chrysene, and were primarily related to concentrations of CoPCs that were detected at station FRT 7C. This station is located adjacent to a non-GM-related outfall and near the mouth of Gilkey Creek, on the western shoreline (opposite the Facility, and one-half mile downstream). FRT 7C also had the highest proportions of clay and organic matter of all unbiased subsurface samples, which may also partially explain the higher concentrations of CoPCs at this station based on what is known about the transport and fate properties of these chemicals (affinity for binding to organic matter and clay).

NEC exceedances for both surface and subsurface sediment were generally infrequent and were often associated with individual samples, suggesting that any adverse effects to benthic organisms would be spatially limited within the Flint River Study Area. The constituents that were identified as CoPCs in the screening process are PAHs and metals. These chemicals have many anthropogenic sources, including atmospheric deposition and other sources that are unrelated to the GM Facility, such as municipal wastewater treatment plants and road runoff. The levels that were detected in the Flint River Study Area sediment are generally within the range of concentrations that would be considered typical for an urban waterway.

In the unbiased data set, surface sediment concentrations were highest at stations FRT 9A and B, located farthest downstream of the Facility and immediately downstream of five non-GM outfalls. Subsurface sediment concentrations were highest in station FRT 7C in the downstream reach near Gilkey Creek and adjacent to a non-GM outfall. The spatial distribution of NEC exceedances indicates that exposure to the CoPCs, and adverse effects, if any, would occur over small areas. The locations of the stations with the highest CoPC concentrations indicate little or no association with the Facility-influenced outfalls, and a greater association with non-GM outfalls and tributaries such as Gilkey Creek (i.e., FRT 7C).

It is also important to consider the toxicological endpoint represented by the screening values. In the case of the NECs, these are no-effect concentrations below which adverse effects to benthic organisms are not likely, and it is not known whether a slight exceedance would result

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Tables

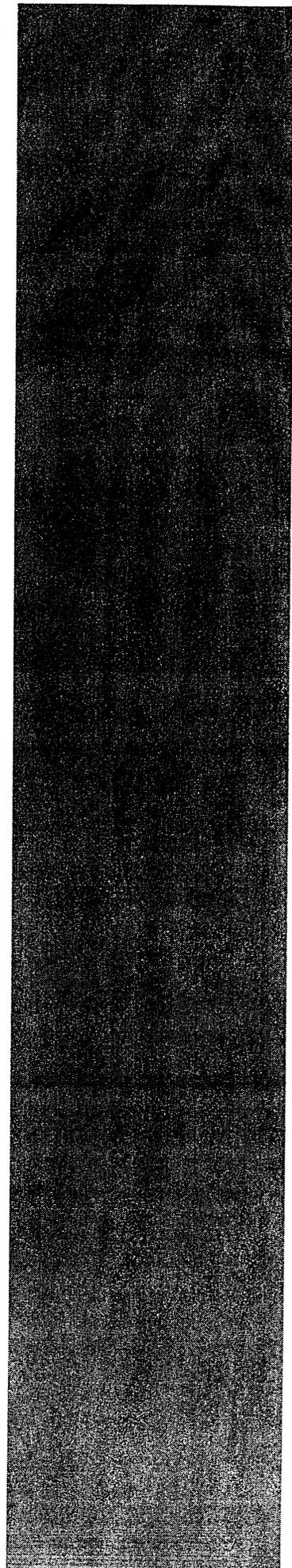


Table 1. (cont.)

Sample ID: Sample Depth (in BGS): Date Collected:	Units	ESL	Adjacent					Downstream					
			FRT 5B	FRT 6B	FRT 7A	FRT 7C	FRT 8B	FRT 9A	FRT 9B	Mean			
			0-2 10/31/06		0-2 10/31/06								
SVOCs													
Benzo[a]pyrene	mg/kg	0.15	0.20 J	0.17 U	0.28 J	0.30 J	0.81 J	0.10 J	1.46 J	1.07 J	0.75 J		
Benzo[b]fluoranthene	mg/kg	10.4	0.20 J	0.17 U	0.30 J	0.89 J	0.17 U	1.685 J	1.32 J	0.87 J			
Benzo[g,h,i]perylene	mg/kg	0.17	0.20 J	0.17 U	0.21 J	0.62 J	0.08 J	1.16 J	0.75 J	0.56 J			
Benzo[k]fluoranthene	mg/kg	0.24	0.20 J	0.07 J	0.24 J	0.82 J	0.17 U	1.335 J	0.88 J	0.70 J			
Chrysene	mg/kg	0.166	0.30 J	0.06 J	0.24 J	0.66 J	0.10 J	1.18 J	0.94 J	0.64 J			
Fluoranthene	mg/kg	0.423	0.48 J	0.10 J	0.43 J	1.20 J	0.10 J	2.2 J	2.05 J	1.20 J			
Fluorene	mg/kg	0.0774	0.17 U	0.17 U	0.15 J	0.10 J	0.17 U	0.1 J	0.1 J	0.13 J			
Indeno[1,2,3-cd]pyrene	mg/kg	0.2	0.10 J	0.17 U	0.17 J	0.52 J	0.06 J	1.035 J	0.67 J	0.50 J			
Pyrene	mg/kg	0.195	0.35 J	0.17 U	0.26 J	0.41 J	0.17 U	1.325 J	1.25 J	0.66 J			
Inorganics													
Chromium (total)	mg/kg	43.4	4.8	5.2	10.2	5.9	7.5	41.2	24.3	15.8	18.9		
Copper	mg/kg	31.6	15.8	10.9	19.5	13.7	33.0 J	4.6	86.15 J	16.6	30.8		
Lead	mg/kg	35.8	16.8	12.2	56.9 J	23.9	34.0 J	8.2	117 J	72.8 J	51.2 J		
Zinc	mg/kg	121	38 J	31 J	42.4 J	50 J	94 J	31 J	302.5 J	312 J	157.8 J		
Miscellaneous													
TOC	mg/kg	--	50	20	--	42	45	15 U	315 J	89	--		
Total Solids	%	--	73	86	--	60	57	75	24	54	--		
Field Parameters													
Clay	%wt	--	-2	-2	--	-2	-2	-2	55.905	-2	--		
Coarse Sand	%wt	--	0.93	10.88	--	3.15	0.24	26.2	0	7.81	--		
Fine Sand	%wt	--	75.91	14.94	--	57.58	82.93	5.84	0	26.94	--		
Grain Density	mm	--	0.31	0.867	--	0.352	0.15	1.751	0.0045	0.632	--		
Gravel	%wt	--	4.98	4.54	--	0.44	0	16.65	0	1.62	--		
Medium Sand	%wt	--	14.91	68.39	--	34.94	3.27	50.42	0	56.01	--		
Silt	%wt	--	-2	-2	--	-2	-2	-2	44.095	-2	--		
Silt/Clay	%wt	--	3.26	1.26	--	3.89	13.56	0.9	100	7.61	--		

Note: -- not available, or not applicable
 % wt - percent by weight
 AVE - average of duplicate sample
 BGS - below ground surface
 ESL - ecological screening level (U.S. EPA 2003)
 J - estimated value
 mg/kg - milligrams per kilogram, dry weight
 ND - not differentiated
 PCB - polychlorinated biphenyl
 SLERA - screening level ecological risk assessment
 SVOC - semivolatile organic compound
 TOC - total organic carbon
 U - undetected

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.

Samples were analyzed for SVOCs, PCBs, and metals, as well as TOC and particle size distribution, by Merit Laboratories of East Lansing, MI.

The 13 constituents that showed statistically higher mean and/or median concentrations between the 3 reaches sampled were retained for the SLERA (refer to Section 3.2 of Flint River Sediment Investigation).

Non-detects shown at half the detection limit.

Boxed values exceed ESL screening value.

Table 2. Screening of surface sediment analytical results for biased sampling transects near GM Outfalls 003, 005, and 013

Sample ID: Sample Depth (in BGS): Date Collected:	Units	Adjacent							Mean
		FRT 11B							
		FRT 10A 10/31/06	FRT 10B 10/31/06	AVE 11/01/06	FRT 11C 11/01/06	FRT 12B 10/31/06	FRT 12C 10/31/06		
SVOCs									
Benzo[a]pyrene	mg/kg	0.15	0.20 J	0.865 J	0.20 J	0.30 J	0.83	0.52 J	
Benzo[b]fluoranthene	mg/kg	10.4	0.17 UJ	0.865 J	0.30 J	0.30 J	0.88 J	0.57 J	
Benzo[g,h,i]perylene	mg/kg	0.17	0.17 U	0.56	0.20 J	0.20 J	0.69	0.41 J	
Benzo[k]fluoranthene	mg/kg	0.24	0.17 UJ	0.695 J	0.20 J	0.30 J	0.75 J	0.44 J	
Chrysene	mg/kg	0.166	0.10 J	0.715	0.20 J	0.20 J	0.65	0.41 J	
Fluoranthene	mg/kg	0.423	0.20 J	1.62 J	0.38	0.37	1.29	0.82 J	
Fluorene	mg/kg	0.0774	0.17 U	0.15 J	0.17 U	0.17 U	0.07 J	0.14 J	
Indeno[1,2,3-cd]pyrene	mg/kg	0.2	0.17 U	0.505	0.20 J	0.20 J	0.58	0.36 J	
Pyrene	mg/kg	0.195	0.17 U	0.8 J	0.17 U	0.17 U	0.46	0.33 J	
Inorganics									
Chromium (total)	mg/kg	43.4	2.8	4.1	3.0	10.5	22.8	8.6	
Copper	mg/kg	31.6	3.3	7.2	17.8	9.1	73.2	22.5	
Lead	mg/kg	35.8	9.1	10.95	10.1	18.7	124.0	34.7	
Zinc	mg/kg	121	18 J	37.45 J	25 J	62 J	316 J	94.0 J	
Miscellaneous									
TOC	mg/kg	--	19	30	32	34	200	--	
Total Solids	%	--	79	80	73	66	20	--	
Field Parameters									
Clay	%wt	--	-2	-2	-2	-2	57.92	--	
Coarse Sand	%wt	--	0.44	10.535	0.20	6.42	0	--	
Fine Sand	%wt	--	84.87	50.15	88.66	23.63	0	--	
Grain Density	mm	--	0.201	0.397	0.294	0.605	0.004	--	
Gravel	%wt	--	3.22	8.755	0	4.73	0	--	
Medium Sand	%wt	--	3.81	28.305	8.24	63.58	0	--	
Silt	%wt	--	-2	-2	-2	-2	42.08	--	
Silt/Clay	%wt	--	6.73	2.255	2.9	1.64	100	--	

Note:
 -- not available, or not applicable
 % wt - percent by weight
 AVE - average of duplicate sample
 BGS - below ground surface
 ESL - ecological screening level (U.S. EPA 2003)
 J - estimated value
 mg/kg - milligrams per kilogram, dry weight
 PCB - polychlorinated biphenyl
 SLERA - screening level ecological risk assessment
 SVOC - semivolatile organic compound
 TOC - total organic carbon
 U - undetected

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.
 Samples were analyzed for SVOCs, PCBs, and metals, as well as TOC and particle size distribution, by Merit Laboratories of East Lansing, MI.

The 13 constituents that showed statistically higher mean and/or median concentrations between the 3 reaches sampled were retained for the SLERA (refer to Section 3.2 of Flint River Sediment Investigation).

Non-detects shown at half the detection limit.

Boxed values exceed ESL screening value.

April 26, 2007

Table 3. Screening of subsurface sediment analytical results for unbiased sampling transects

Sample ID: Sample Depth (in BGS): Date Collected: Units	Upstream						Adjacent	
	FRT 2C 2-12 11/01/06	FRT 2C 12-24 11/01/06	FRT 2C 24-36 11/01/06	FRT 2C 36-48 11/01/06	FRT 2C 48-57 11/01/06	FRT 4A 2-12 11/01/06	FRT 4A 12-24 11/01/06	Mean
	ESL	ESL	ESL	ESL	ESL	ESL	ESL	ESL
SVOCs								
Benzo[a]pyrene	0.15	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.18 J
Benzo[b]fluoranthene	10.4	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.13 J
Benzo[g,h,i]perylene	0.17	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.13 J
Benzo[k]fluoranthene	0.24	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.13 J
Chrysene	0.166	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.13 J
Fluoranthene	0.423	0.03 J	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.18 J
Fluorene	0.0774	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U
Indeno[1,2,3-cd]pyrene	0.2	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.13 J
Pyrene	0.195	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U
Inorganics								
Chromium (total)	43.4	8.9	2.1	1.0 U	1.0 U	3.9	2.5	1.8
Copper	31.6	7.0	1.7	1.2	0.5 U	3.7	7.3	4.5
Lead	35.8	6.6	1.6	1.6	0.5 U	3.8	7.9	4.9
Zinc	121	30	6	6	4	16.1	15	13.6
Miscellaneous								
TOC	--	50	22	30	12 U	--	19	--
Total Solids	--	63	68	71	83	--	79	--
Field Parameters								
Clay	--	-2	-2	-2	1.07	--	-2	--
Coarse Sand	--	10.24	1.78	0.74	0	--	12.44	--
Fine Sand	--	47.24	56.15	80.52	64.29	--	42.39	--
Grain Density	--	0.35	0.338	0.283	0.339	--	0.473	--
Gravel	--	6.82	0	2.9	0	--	16.88	--
Medium Sand	--	26.77	30.54	9.21	30.88	--	23.83	--
Silt	--	-2	-2	-2	3.77	--	-2	--
Silt/Clay	--	8.92	4.41	6.63	4.83	--	4.46	--

Table 3. (cont.)

Sample Depth (in BGS):	Date Collected:	Units	ESL	Downstream				Mean
				FRT 7C		FRT 7C		
				2-12	12-24	24-36	36-46	
Sample ID:	39021	AVE						
SVOCS								
Benzo[a]pyrene	mg/kg	0.15	7.00	0.53	0.17	2.05		
Benzo[b]fluoranthene	mg/kg	10.4	4.00	0.30	0.17	1.49		
Benzo[g,h,i]perylene	mg/kg	0.17	3.00	0.35	0.17	1.00		
Benzo[k]fluoranthene	mg/kg	0.24	4.00	0.30	0.17	1.34		
Chrysene	mg/kg	0.166	7.00	0.38	0.17	2.26		
Fluoranthene	mg/kg	0.423	7.00	0.39	0.17	2.24		
Fluorene	mg/kg	0.0774	7.00	0.10	0.17	0.32		
Indeno[1,2,3-cd]pyrene	mg/kg	0.2	3.00	0.30	0.17	0.99		
Pyrene	mg/kg	0.195	12.0	0.17	0.17	3.21		
Inorganics								
Chromium (total)	mg/kg	43.4	64.4	6.5	2.3	52.3		
Copper	mg/kg	31.6	127.0	7.9	3.4	68.3		
Lead	mg/kg	35.8	183.0	10.3	3.8	104.5		
Zinc	mg/kg	121	338	22	12	254.2		
Miscellaneous								
TOC	mg/kg	--	180	89	47	--		
Total Solids	%	--	62.5	66	75	--		
Field Parameters								
Clay	%wt	--	59.645	59.02	11.15	--		
Coarse Sand	%wt	--	0	0	0	--		
Fine Sand	%wt	--	0	0	0	--		
Grain Density	mm	--	0.004	0.004	0.097	--		
Gravel	%wt	--	0	0	0	--		
Medium Sand	%wt	--	0	0	0	--		
Silt	%wt	--	40.355	36.62	0.89	--		
Silt/Clay	%wt	--	100	40.98	34.5	--		
				100	45.66	--		

Note: -- not available, or not applicable; %wt - percent by weight; AVE - average of duplicate sample; BGS - below ground surface; ESL - ecological screening level (U.S. EPA 2003); J - estimated value; mg/kg - milligrams per kilogram, dry weight; PCB - polychlorinated biphenyl; SLERA - screening level ecological risk assessment; SVOC - semivolatle organic compound; TOC - total organic carbon; U - undetected

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006. Samples were analyzed for SVOCs, PCBs, and metals, as well as TOC and particle size distribution, by Merit Laboratories of East Lansing, MI.

The 13 constituents that showed statistically higher mean and/or median concentrations between the 3 reaches sampled were retained for the SLERA (refer to Section 3.2 of Flint River Sediment Investigation).

Non-detects shown at half the detection limit.

Boxed values exceed ESL screening value.

Table 4. Screening of subsurface sediment analytical results for biased transects near GM Outfalls 003, 005, and 013

Sample ID: Sample Depth (in BGS): Date Collected:	Units	ESL	Adjacent			Mean
			FRT 12C 2-12 11/01/06	FRT 12C 12-24 11/01/06	FRT 12C 24-36 11/01/06	
SVOCs						
Benzo[a]pyrene	mg/kg	0.15	1.77	0.99	0.20 J	0.99 J
Benzo[b]fluoranthene	mg/kg	10.4	2.20 J	1.18 J	0.30 J	1.23 J
Benzo[g,h,i]perylene	mg/kg	0.17	1.41	0.82	0.20 J	0.81 J
Benzo[k]fluoranthene	mg/kg	0.24	1.45 J	0.93 J	0.20 J	0.86 J
Chrysene	mg/kg	0.166	1.54	0.88	0.20 J	0.87 J
Fluoranthene	mg/kg	0.423	3.05	1.69	0.41	1.72
Fluorene	mg/kg	0.0774	0.20 J	0.10 J	0.17 U	0.16 J
Indeno[1,2,3-cd]pyrene	mg/kg	0.2	1.16	0.69	0.10 J	0.65
Pyrene	mg/kg	0.195	2.02	0.84	0.17 U	1.01
Inorganics						
Chromium (total)	mg/kg	43.4	16.0	8.4	7.2	10.5
Copper	mg/kg	31.6	48.0	8.9	13.1	23.3
Lead	mg/kg	35.8	72.3	14.0	20.8	35.7
Zinc	mg/kg	121	229	41	44	104.8
Miscellaneous						
TOC	mg/kg	--	88	27	26	--
Total Solids	%	--	41	76	78	--
Field Parameters						
Clay	%wt	--	-2	-2	-2	--
Coarse Sand	%wt	--	0.4	0.35	0.24	--
Fine Sand	%wt	--	54.18	82.09	80.87	--
Grain Density	mm	--	0.195	0.311	0.302	--
Gravel	%wt	--	0	0.86	0.22	--
Medium Sand	%wt	--	24.78	15.49	14.84	--
Silt	%wt	--	-2	-2	-2	--
Silt/Clay	%wt	--	20.64	1.21	3.83	--

Note:

-	- not available, or not applicable
% wt	- percent by weight
AVE	- average of duplicate sample
BGS	- below ground surface
ESL	- ecological screening level (U.S. EPA 2003)
J	- estimated value
mg/kg	- milligrams per kilogram, dry weight
PCB	- polychlorinated biphenyl
SLERA	- screening level ecological risk assessment
SVOC	- semivolatile organic compound
TOC	- total organic carbon
U	- undetected

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.

Samples were analyzed for SVOCs, PCBs, and metals, as well as TOC and particle size distribution, by Merit Laboratories of East Lansing, MI.

The 13 constituents that showed statistically higher mean and/or median concentrations between the 3 reaches sampled were retained for the SLERA (refer to Section 3.2 of Flint River Sediment Investigation).

Non-detects shown at half the detection limit.

Boxed values exceed ESL screening value.

Table 5. Secondary screening of surface sediment analytical results for unbiased sampling transects

Sample ID: Sample Depth (in BGS): Date Collected:	Units	NEC	Adjacent						Mean
			FRT 4A 0-2 11/01/06	FRT 4C 0-2 11/01/06	FRT 5A 0-2 10/31/06	FRT 5B 0-2 10/31/06	FRT 6B 0-2 10/31/06		
SVOCs									
Benzo[a]pyrene	mg/kg	1	0.20 J	0.62 J	0.20 J	0.20 J	0.17 U	0.28 J	
Benzo[g,h,i]perylene	mg/kg	1.2	0.10 J	0.47	0.10 J	0.20 J	0.17 U	0.21 J	
Benzo[k]fluoranthene	mg/kg	4	0.20 J	0.53 J	0.20 J	0.20 J	0.07 J	0.24 J	
Chrysene	mg/kg	3	0.20 J	0.54	0.10 J	0.30 J	0.06 J	0.24 J	
Fluoranthene	mg/kg	10	0.30 J	1.08	0.20 J	0.48	0.10 J	0.43 J	
Fluorene	mg/kg	3	0.17 U	0.09 J	0.17 U	0.17 U	0.17 U	0.15 J	
Indeno[1,2,3-cd]pyrene	mg/kg	0.77	0.10 J	0.39	0.10 J	0.10 J	0.17 U	0.17 J	
Pyrene	mg/kg	9	0.17 U	0.46	0.17 U	0.35	0.17 U	0.26	
Inorganics									
Copper	mg/kg	580	13.5	31.2	25.9	15.8	10.9	19.5	
Lead	mg/kg	130	15.4	26.0	214.0	16.8	12.2	56.9	
Zinc	mg/kg	1,300	28 J	72 J	43 J	38 J	31 J	42.4 J	

Table 5. (cont.)

Sample ID: Sample Depth (in BGS): Date Collected: Units NEC	Downstream					Mean
	FRT 7A	FRT 7C	FRT 8B	FRT 9A	FRT 9B	
	0-2 10/31/06	0-2 10/31/06	0-2 10/31/06	0-2 10/31/06 AVE	0-2 10/31/06	
SVOCs						
Benzo[a]pyrene	mg/kg 1	0.30 J	0.81 J	0.10 J	1.46 J	0.75 J
Benzo[g,h,i]perylene	mg/kg 1.2	0.20 J	0.62 J	0.08 J	1.16	0.56 J
Benzo[k]fluoranthene	mg/kg 4	0.30 J	0.82 J	0.17 UJ	1.335 J	0.70 J
Chrysene	mg/kg 3	0.30 J	0.66 J	0.10 J	1.18	0.64 J
Fluoranthene	mg/kg 10	0.44	1.20 J	0.10 J	2.2 J	1.20 J
Fluorene	mg/kg 3	0.17 U	0.10 J	0.17 U	0.1 J	0.13 J
Indeno[1,2,3-cd]pyrene	mg/kg 0.77	0.20 J	0.52 J	0.06 J	1.035	0.50 J
Pyrene	mg/kg 9	0.17 U	0.41 J	0.17 U	1.325	0.66 J
Inorganics						
Copper	mg/kg 580	13.7	33.0	4.6	86.15	30.8
Lead	mg/kg 130	23.9	34.0	8.2	117	51.2
Zinc	mg/kg 1300	50 J	94 J	31 J	302.5 J	158 J

Note: AVE - average of duplicate sample
 BGS - below ground surface
 ESL - ecological screening level
 J - estimated value
 mg/kg - milligrams per kilogram, dry weight
 NEC - no effects concentration (Ingersoll et al. 1996)
 PCB - polychlorinated biphenyl
 SVOC - semivolatle organic compound
 U - undetected

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.

Samples were analyzed for SVOCs, PCBs, and metals, as well as total organic carbon and particle size distribution, by Merit Laboratories of East Lansing, MI.

Chemicals that exceeded ESLs, or for which no ESLs were available, were retained for secondary screening (refer to Table 1).

Non-detects shown at half the detection limit.

Boxed values exceed NEC screening value.

Table 6. Secondary screening of surface sediment analytical results for biased sampling transects near GM Outfalls 003, 005, and 013

Sample ID: Sample Depth(in BGS): Date Collected:	Adjacent						Mean
	FRT 10A 0-2 10/31/06	FRT 10B 0-2 10/31/06	FRT 11B 0-2 11/01/06 AVE	FRT 11C 0-2 11/01/06	FRT 12B 0-2 10/31/06	FRT 12C 0-2 10/31/06	
SVOCs	NEC	NEC	AVE	NEC	NEC	NEC	
Benzof[a]pyrene	1 mg/kg	0.73	0.20 J	0.865	0.20 J	0.30 J	0.83
Benzof[g,h,i]perylene	1.2 mg/kg	0.65	0.17 U	0.56	0.20 J	0.20 J	0.69
Benzof[k]fluoranthene	4 mg/kg	0.51 J	0.17 UJ	0.695 J	0.20 J	0.30 J	0.75 J
Chrysene	3 mg/kg	0.58	0.10 J	0.715	0.20 J	0.20 J	0.65
Fluoranthene	10 mg/kg	1.05	0.20 J	1.62 J	0.38	0.37	1.29
Fluorene	3 mg/kg	0.10 J	0.17 U	0.15 J	0.17 U	0.17 U	0.07 J
Indeno[1,2,3-cd]pyrene	0.77 mg/kg	0.50	0.17 U	0.505	0.20 J	0.20 J	0.58
Pyrene	9 mg/kg	0.20 J	0.17 U	0.8 J	0.17 U	0.17 U	0.46
Inorganics							
Copper	580 mg/kg	24.4	3.3	7.2	17.8	9.1	73.2
Lead	130 mg/kg	35.3	9.1	10.95	10.1	18.7	124.0
Zinc	1,300 mg/kg	105	18 J	37.45 J	25 J	62 J	316 J
							94 J

- Note:**
- AVE - average of duplicate sample
 - BGS - below ground surface
 - ESL - ecological screening level
 - J - estimated value
 - mg/kg - milligrams per kilogram, dry weight
 - NEC - no effects concentration (Ingersoll et al. 1996)
 - PCB - polychlorinated biphenyl
 - SVOC - semivolatile organic compound
 - U - undetected

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006. Samples were analyzed for SVOCs, PCBs, and metals, as well as total organic carbon and particle size distribution, by Merit Laboratories of East Lansing, MI.

Chemicals that exceeded ESLs, or for which no ESLs were available, were retained for secondary screening (refer to Table 2). Non-detects shown at half the detection limit.

Boxed values exceed NEC screening value.

Table 7. Secondary screening of subsurface sediment analytical results for unbiased sampling transects

Sample ID: Sample Depth (in BGS): Date Collected: Units	Adjacent		Downstream						
	FRT 4A 2-12 11/01/06	FRT 4A 12-24 11/01/06	FRT 7C 2-12 10/31/06	FRT 7C 12-24 10/31/06	FRT 7C 24-36 10/31/06	FRT 7C 36-46 10/31/06	Mean		
SVOCs	NEC	NEC	AVE						
Benzoflapyrene	1	0.20 J	0.17 U	0.18 J	0.5 U	7.00 J	0.53	0.17 U	2.05
Benzofl, h, i]perylene	1.2	0.10 J	0.17 U	0.13 J	0.5 U	3.00 J	0.35	0.17 U	1.00 J
Benzofl, k]fluoranthene	4	0.10 J	0.17 U	0.13 J	0.9 J	4.00 J	0.30 J	0.17 U	1.34 J
Chrysene	3	0.10 J	0.17 U	0.13 J	1.5	7.00 J	0.38	0.17 U	2.26
Fluoranthene	10	0.20 J	0.17 U	0.18 J	1.4 J	7.00	0.39	0.17 U	2.24 J
Fluorene	3	0.17 U	0.17 U	0.17 U	0.5 U	0.50 U	0.10 J	0.17 U	0.32 J
Indeno[1,2,3-cd]pyrene	0.77	0.09 J	0.17 U	0.13 J	0.5 U	3.00 J	0.30 J	0.17 U	0.99 J
Pyrene	9	0.17 U	0.17 U	0.17 U	0.5 U	12.0	0.17 U	0.17 U	3.21
Inorganics									
Chromium (total)	95	2.5	1.0 U	1.8	136	64.4	6.5	2.3	52.3
Copper	580	7.3	1.7	4.5	135	127.0	7.9	3.4	68.3
Lead	130	7.9	1.8	4.9	221	183.0	10.3	3.8	104.5
Zinc	1,300	15	12	14	645	338	22	12	254

Note: AVE - average of duplicate sample

BGS - below ground surface

ESL - ecological screening level

J - estimated value

mg/kg - milligrams per kilogram, dry weight

NEC - no effects concentration (Ingersoll et al. 1996)

PCB - polychlorinated biphenyl

SVOC - semivolatile organic compound

U - undetected

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.

Samples were analyzed for SVOCs, PCBs, and metals, as well as total organic carbon and particle size distribution, by Merit Laboratories of East Lansing, MI.

Chemicals that exceeded ESLs, or for which no ESLs were available, were retained for secondary screening (refer to Table 3).

Non-detects shown at half the detection limit.

Boxed values exceed NEC screening value.

Table 8. Secondary screening of subsurface sediment analytical results for biased transects near GM Outfalls 003, 005, and 013

Sample ID: Sample Depth (in BGS): Date Collected:	Units	NEC	Adjacent			Mean
			FRT 12C 2-12 11/01/06	FRT 12C 12-24 11/01/06	FRT 12C 24-36 11/01/06	
SVOCs						
Benzof[a]pyrene	mg/kg	1	1.77	0.99	0.20 J	0.99 J
Benzof[g,h,i]perylene	mg/kg	1.2	1.41	0.82	0.20 J	0.81 J
Benzof[k]fluoranthene	mg/kg	4	1.45 J	0.93 J	0.20 J	0.86 J
Chrysene	mg/kg	3	1.54	0.88	0.20 J	0.87 J
Fluoranthene	mg/kg	10	3.05	1.69	0.41	1.72
Fluorene	mg/kg	3	0.20 J	0.10 J	0.17 U	0.16 J
Indeno[1,2,3-cd]pyrene	mg/kg	0.77	1.16	0.69	0.10 J	0.65
Pyrene	mg/kg	9	2.02	0.84	0.17 U	1.01
Inorganics						
Copper	mg/kg	580	48.0	8.9	13.1	23.3
Lead	mg/kg	130	72.3	14.0	20.8	35.7
Zinc	mg/kg	1300	229	41	44	105

Note:
 AVE - average of duplicate sample
 BGS - below ground surface
 ESL - ecological screening level
 J - estimated value
 mg/kg - milligrams per kilogram, dry weight
 NEC - no effects concentration (Ingersoll et al. 1996)
 PCB - polychlorinated biphenyl
 SVOC - semivolatile organic compound
 U - undetected

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.

Samples were analyzed for SVOCs, PCBs, and metals, as well as total organic carbon and particle size distribution, by Merrit Laboratories of East Lansing, MI.

Chemicals that exceeded ESLs, or for which no ESLs were available, were retained for secondary screening (refer to Table 4).

Non-detects shown at half the detection limit.

Boxed values exceed NEC screening value.

April 26, 2007

Table 9. Comparison of surface sediment analytical results for unbiased sampling transects to regional and urban background levels

Sample ID: Sample Depth (in BGS): Date Collected:	Units	Background Levels				Adjacent						Mean						
		Urban		Statewide		FRT 4A		FRT 4C		FRT 5A			FRT 5B		FRT 6B			
		Min	Max	Min	Max	0-2	11/01/06	0-2	11/01/06	0-2	10/31/06		0-2	10/31/06	0-2	10/31/06		
SVOCS																		
Benzof[a]pyrene	mg/kg	0.165	0.22 ^a	--	--	0.20	J	0.62	J	0.20	J	0.20	J	0.17	U	0.28	J	
Benzof[g,h,i]perylene	mg/kg	0.9	47 ^a	--	--	0.10	J	0.47	J	0.10	J	0.20	J	0.17	U	0.21	J	
Benzof[k]fluoranthene	mg/kg	0.3	26 ^a	--	--	0.20	J	0.53	J	0.20	J	0.20	J	0.07	J	0.24	J	
Chrysene	mg/kg	0.251	0.64 ^a	--	--	0.20	J	0.54	J	0.10	J	0.30	J	0.06	J	0.24	J	
Fluoranthene	mg/kg	0.2	166 ^a	--	--	0.30	J	1.08	J	0.20	J	0.48	J	0.10	J	0.43	J	
Fluorene	mg/kg	--	--	--	--	0.17	U	0.09	J	0.17	U	0.17	U	0.17	U	0.15	J	
Indeno[1,2,3-cd]pyrene	mg/kg	8	61 ^a	--	--	0.10	J	0.39	J	0.10	J	0.10	J	0.17	U	0.17	J	
Pyrene	mg/kg	0.145	147 ^a	--	--	0.17	U	0.46	J	0.17	U	0.35	J	0.17	U	0.26	J	
Inorganics																		
Copper	mg/kg	30	113 ^b	<2	25 ^c	13.5	J	31.2	J	25.9	J	15.8	J	10.9	J	19.5	J	
Lead	mg/kg	93	160 ^b	<5	50 ^c	15.4	J	26.0	J	214.0	J	16.8	J	12.2	J	56.9	J	
Zinc	mg/kg	120	257 ^b	<5	170 ^c	28.2	J	72.3	J	43.1	J	38	J	31	J	42.4	J	

Table 9. (cont.)

Sample ID: Sample Depth (in BGS): Date Collected:	Background Levels				Downstream					Mean				
	Urban		Statewide		FRT 7A	FRT 7C	FRT 8B	FRT 9A	FRT 9B					
	Min	Max	Min	Max	0-2 10/31/06	0-2 10/31/06	0-2 10/31/06	0-2 10/31/06	0-2 10/31/06					
SVOCs	Units													
Benz[a]pyrene	mg/kg	0.165	0.22	a	--	--	--	--	0.30 J	0.81 J	0.10 J	1.46 J	1.07 J	0.75 J
Benz[ghi]perylene	mg/kg	0.9	47	a	--	--	--	--	0.20 J	0.62 J	0.08 J	1.16 J	0.75 J	0.56 J
Benz[k]fluoranthene	mg/kg	0.3	26	a	--	--	--	--	0.30 J	0.82 J	0.17 U	1.335 J	0.88 J	0.70 J
Chrysene	mg/kg	0.251	0.64	a	--	--	--	--	0.30 J	0.66 J	0.10 J	1.18 J	0.94 J	0.64 J
Fluoranthene	mg/kg	0.2	166	a	--	--	--	--	0.44 J	1.20 J	0.10 J	2.2 J	2.05 J	1.20 J
Fluorene	mg/kg	--	--	--	--	--	--	--	0.17 U	0.10 J	0.17 U	0.1 J	0.10 J	0.13 J
Indeno[1,2,3-cd]pyrene	mg/kg	8	61	a	--	--	--	--	0.20 J	0.52 J	0.06 J	1.035 J	0.67 J	0.50 J
Pyrene	mg/kg	0.145	147	a	--	--	--	--	0.17 U	0.41 J	0.17 U	1.325 J	1.25 J	0.66 J
Inorganics														
Copper	mg/kg	30	113	b	<2	25	c		13.7	33.0	4.6	86.15	16.6	30.8
Lead	mg/kg	93	160	b	<5	50	c		23.9	34.0	8.2	117	72.8	51.2
Zinc	mg/kg	120	257	b	<5	170	c		50 J	94 J	31 J	302.5 J	312 J	157.8 J

Note: AVE - average of duplicate sample
 BGS - below ground surface
 J - estimated value
 mg/kg - milligrams per kilogram, dry weight
 PCB - polychlorinated biphenyl
 SLEERA - screening level ecological risk assessment
 SVOC - semi-volatile organic compound
 U - undetected at detection limit shown

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.
 Samples were analyzed for SVOCs, PCBs, and metals, as well as total organic carbon and particle size distribution, by Merit Laboratories of East Lansing, MI.
 Chemicals that exceeded ESLs, or for which no ESLs were available, were retained for background screening (refer to Table 1).
 Non-detects shown at half the detection limit.
 Boxed values exceed the upper range (max) of urban background values.^{a,b}
 Bold values exceed the upper range (max) of reference site background values.^c
^aBackground soil concentrations of PAHs in urban soil (ATSDR 1995).
^bMean concentrations of metals in Michigan surface soils for residential, commercial, and industrial land uses (Murray et al. 2004)
^cStatewide reference sediment chemistry for all ecoregions (MDEQ 1999)

Table 10. Comparison of surface sediment analytical results for biased sampling transects near GM Outfalls 003, 005, and 013 to regional and urban background levels

Sample ID: Sample Depth (in BGS): Date Collected:	Background Levels				Adjacent					Mean		
	Urban		Statewide		FRT 10A 0-2 10/31/06	FRT 10B 0-2 10/31/06	FRT 11B 0-2 11/01/06 AVE	FRT 11C 0-2 11/01/06	FRT 12B 0-2 10/31/06		FRT 12C 0-2 10/31/06	
	Units	Min	Max	Min								Max
SVOCs												
Benzol[a]pyrene	mg/kg	0.165	0.22	a	--	--	0.73	0.20 J	0.30 J	0.83	0.52 J	
Benzol[g,h,i]perylene	mg/kg	0.9	47	a	--	--	0.65	0.17 U	0.20 J	0.69	0.41 J	
Benzol[k]fluoranthene	mg/kg	0.3	26	a	--	--	0.51 J	0.17 U	0.20 J	0.75 J	0.44 J	
Chrysene	mg/kg	0.251	0.64	a	--	--	0.58	0.10 J	0.20 J	0.20 J	0.41 J	
Fluoranthene	mg/kg	0.2	166	a	--	--	1.05	0.20 J	0.38	1.29	0.82 J	
Fluorene	mg/kg	--	--	--	--	--	0.10 J	0.17 U	0.17 U	0.17 U	0.14 J	
Indeno[1,2,3-cd]pyrene	mg/kg	8	61	a	--	--	0.50	0.17 U	0.20 J	0.58	0.36 J	
Pyrene	mg/kg	0.145	147	a	--	--	0.20 J	0.17 U	0.17 U	0.46	0.33 J	
Inorganics												
Copper	mg/kg	30	113	b	<2	25	24.4	3.3	7.2	17.8	9.1	73.2
Lead	mg/kg	93	160	b	<5	50	35.3	9.1	10.95	10.1	18.7	124.0
Zinc	mg/kg	120	257	b	<5	170	105	18 J	37.45 J	25 J	62 J	316 J

Note: AVE - average of duplicate sample
 BGS - below ground surface
 J - estimated value
 U - milligrams per kilogram, dry weight

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.

Samples were analyzed for SVOCs, PCBs, and metals, as well as total organic carbon and particle size distribution, by Merit Laboratories of East Lansing, MI.

Chemicals that exceeded ESLs, or for which no ESLs were available, were retained for background screening (refer to Table 2).

Non-detects shown at half the detection limit:
 Boxed values exceed the upper range (max) of urban background values;^{a,b}
 Bold values exceed the upper range (max) of reference site background values;^c

^aBackground soil concentrations of PAHs in urban soil (ATSDR 1995).
^bMean concentrations of metals in Michigan surface soils for residential, commercial, and industrial land uses (Murray et al. 2004)
^cStatewide reference sediment chemistry for all ecoregions (MDEQ 1999)

Table 11. Comparison of subsurface sediment analytical results for unbiased sampling transects to regional and urban background levels

Sample ID: Sample Depth (in BGS): Date Collected: Units	Background Levels				Adjacent			Downstream				
	Urban		Statewide		FRT 4A 2-12	FRT 4A 12-24	Mean	FRT 7C 2-12	FRT 7C 12-24	FRT 7C 24-36	FRT 7C 36-46	Mean
	Min	Max	Min	Max	11/01/06	11/01/06	10/31/06 AVE	10/31/06	10/31/06	10/31/06		
SVOCs												
Benzof[a]pyrene	mg/kg	0.165	0.22	a	--	--	0.20 J	0.17 U	0.18 J	0.53	0.17 U	2.05
Benzof[g,h,i]perylene	mg/kg	0.9	47	a	--	--	0.10 J	0.17 U	0.13 J	0.35	0.17 U	1.00
Benzof[k]fluoranthene	mg/kg	0.3	26	a	--	--	0.10 J	0.17 U	0.13 J	0.30 J	0.17 U	1.34
Chrysene	mg/kg	0.251	0.64	a	--	--	0.10 J	0.17 U	0.13 J	0.38	0.17 U	2.26
Fluoranthene	mg/kg	0.2	166	a	--	--	0.20 J	0.17 U	0.18 J	0.39	0.17 U	2.24
Fluorene	mg/kg	--	--	--	--	--	0.17 U	0.17 U	0.17 U	0.10 J	0.17 U	0.32
Indeno[1,2,3-cd]pyrene	mg/kg	8	61	a	--	--	0.09 J	0.17 U	0.13 J	0.30 J	0.17 U	0.99
Pyrene	mg/kg	0.145	147	a	--	--	0.17 U	0.17 U	0.17 U	0.17 U	0.17 U	3.21
Inorganics												
Chromium (Total)	mg/kg	27	55	b	<2	65	2.5	1.0 U	1.8	6.5	2.3	52.3
Copper	mg/kg	30	113	b	<2	25	7.3	1.7	4.5	7.9	3.4	68.3
Lead	mg/kg	93	160	b	<5	50	7.9	1.8	4.9	10.3	3.8	104.5
Zinc	mg/kg	120	257	b	<5	170	15	12	13.6	22	12	254.2

Note: AVE - average of duplicate sample
BGS - below ground surface
J - estimated value

- mg/kg - milligrams per kilogram, dry weight
- PCB - polychlorinated biphenyl
- SLERA - screening level ecological risk assessment
- SVOC - semivolatile organic compound
- U - undetected at detection limit shown

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.

Samples were analyzed for SVOCs, PCBs, and metals, as well as total organic carbon and particle size distribution by Merit Laboratories of East Lansing, MI.

Chemicals that exceeded ESLs, or for which no ESLs were available, were retained for background screening (refer to Table 3).

Non-detects shown at half the detection limit.

Boxed values exceed the upper range (max) of urban background values.^{a,b}

Bold values exceed the upper range (max) of reference site background values.^c

^aBackground soil concentrations of PAHs in urban soil (ATSDR 1995).

^bMean concentrations of metals in Michigan surface soils for residential, commercial, and industrial land uses (Murray et al. 2004)

^cStatewide reference sediment chemistry for all ecoregions (MDEQ 1999)

Table 12. Comparison of subsurface sediment analytical results for biased transects Near GM Outfalls 003, 005, and 013 to regional and urban background levels

Sample ID: Sample Depth (in BGS): Date Collected:	Background Levels				Adjacent			
	Urban		Statewide		FRT 12C 2-12	FRT 12C 12-24	FRT 12C 24-36	Mean
	Units	Min	Max	Min	Max	Min	Max	
SVOCs								
Benz[a]pyrene	mg/kg	0.165	0.22	a				
Benzol[g,h,i]perylene	mg/kg	0.9	47	a	1.77	0.99	0.20 J	0.99 J
Benzol[k]fluoranthene	mg/kg	0.3	26	a	1.41	0.82	0.20 J	0.81 J
Chrysene	mg/kg	0.251	0.64	a	1.45 J	0.93 J	0.20 J	0.86 J
Fluoranthene	mg/kg	0.2	166	a	1.54	0.88	0.20 J	0.87 J
Fluorene	mg/kg	--	--	--	3.05	1.69	0.41	1.72
Indeno[1,2,3-cd]pyrene	mg/kg	8	61	a	0.20 J	0.10 J	0.17 U	0.16 J
Pyrene	mg/kg	0.145	147	a	1.16	0.69	0.10 J	0.65 J
Inorganics								
Copper	mg/kg	30	113	b	2.02	0.84	0.17 U	1.01
Lead	mg/kg	93	160	b	48.0	8.9	13.1	23.3
Zinc	mg/kg	120	257	b	72.3	14.0	20.8	35.7
					229	41	44	104.8

Note: AVE - average of duplicate sample
BGS - below ground surface

- J - estimated value
- mg/kg - milligrams per kilogram, dry weight
- PCB - polychlorinated biphenyl
- SLEERA - screening level ecological risk assessment
- SVOC - semivolatile organic compound
- U - undetected at detection limit shown

Sampling was performed by ARCADIS BBL and Exponent during the week of October 30, 2006.
 Samples were analyzed for SVOCs, PCBs, and metals, as well as total organic carbon and particle size distribution, by Merit Laboratories of East Lansing, MI.
 Chemicals that exceeded ESLs, or for which no ESLs were available, were retained for background screening (refer to Table 4).
 Non-detects shown at half the detection limit.
 Boxed values exceed the upper range (max) of urban background values.^{a,b}
 Bold values exceed the upper range (max) of reference site background values.^c
^aBackground soil concentrations of PAHs in urban soil (ATSDR 1995).
^bMean concentrations of metals in Michigan surface soils for residential, commercial, and industrial land uses (Murray et al. 2004)
^cStatewide reference sediment chemistry for all ecoregions (MDEQ 1999)

Table 13. Weight-of-evidence summary for unbiased and biased surface sediment samples

	Exceeds ESLs		Exceeds NECs		Exceeds Regional Background		Exceeds Urban Background	
	UP	ADJ	ADJ	DOWN	ADJ	DOWN	ADJ	DOWN
SVOCs								
Benzol[a]pyrene	X	X		X	--	--	X	X
Benzol[g,h,i]perylene	X	X		X	--	--		
Benzol[k]fluoranthene	X	X		X	--	--		
Chrysene	X	X		X	--	--	X	X
Fluoranthene	X	X		X	--	--		
Fluorene	X	X		X	--	--		
Indeno[1,2,3-cd]pyrene	X	X		X	--	--		
Pyrene	X	X		X	--	--		
Inorganics								
Copper		X		X		X		X
Lead	X	X		X	X	X	X	X
Zinc	X	X		X	X	X	X	X

Note: -- not applicable

ADJ - adjacent

DOWN - downstream

ESL - ecological screening level (U.S. EPA 2003)

NEC - no effects concentration (Ingersoll et al. 1996)

UP - upstream

X - exceeds detected or estimated concentration in one or more samples

Boxed cells indicate the mean concentration exceeds.

Table 14. Weight-of-evidence summary for unbiased and biased subsurface sediment samples

	Exceeds ESLs		Exceeds NECs		Exceeds Regional Background		Exceeds Urban Background	
	UP	ADJ	ADJ	DOWN	ADJ	DOWN	ADJ	DOWN
SVOCS								
Benzo[a]pyrene	X	X	X	X	--	--		X
Benzo[g,h,i]perylene	X	X	X	X	--	--		
Benzo[k]fluoranthene	X	X			--	--		
Chrysene	X	X	X		--	--		X
Fluoranthene	X	X			--	--		
Fluorene	X	X			--	--		
Indeno[1,2,3-cd]pyrene	X	X	X	X	--	--		
Pyrene	X	X			--	--		
Inorganics								
Chromium (total)				X		X		X
Copper	X	X				X		X
Lead	X	X				X		X
Zinc	X	X				X		X

Note:

- not applicable
- ADJ - adjacent
- DOWN - downstream
- ESL - ecological screening level (U.S. EPA 2003)
- NEC - no effects concentration (Ingersoll et al. 1996)
- UP - upstream
- X - exceeds detected or estimated concentration in one or more samples

Boxed cells indicate the mean concentration exceeds.