Total Maximum Daily Loads for PCBs in the Houston Ship Channel

Contract No. 582-6-70860
Work Order No. 582-6-70860-13

Final Report

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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY AND
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CHAPTER 1 - INTRODUCTION

Polychlorinated biphenyls (PCBs) are widespread organic contaminants which are environmentally persistent and can be harmful to human health even at low concentrations. A major route of exposure for PCBs worldwide is through food consumption, and this route is especially significant in seafood. The discovery of PCBs in seafood tissue has led Texas Department of State Health Services to issue seafood consumption advisories, and some of these advisories have been issued for the Houston Ship Channel (HSC). Two specific advisories have been issued recently for all finfish species based on concentrations of PCBs, organochlorine pesticides, and dioxins. ADV-20 was issued in October 2001 and includes the HSC upstream of the Lynchburg Ferry crossing and all contiguous waters, including the San Jacinto River Tidal below the U.S. Highway 90 bridge. ADV-28 was issued in January 2005 for Upper Galveston Bay (UGB) and the HSC and all contiguous waters north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. These two advisories represent a large surface water system for which TMDLs need to be developed and implemented.

1.1 SCOPE OF THE PROJECT

The scope of the PCB TMDL project includes studies and implementations related only to PCBs in the HSC System including Upper Galveston Bay. The work included in the scope currently includes project administration, participation in stakeholder involvement, development of a monitoring plan, and preparation of sampling and modeling Quality Assurance Project Plans (QAPPs).

1.2 DESCRIPTION OF THE REPORT

This document comprises the final report for FY07 for the TMDL PCB project and summarizes the results of the activities undertaken by the University of Houston for Work Order No.582-6-70860-13 during the period from September 11, 2006 to August 31, 2007.

This report summarizes the project activities that have been conducted throughout fiscal year 2007, some activities that have already been reported in previous quarterlies and some activities that will be presented here for the first time. Of the first category, project activities include detailed literature review, review and analysis of previously collected PCB data, development of a monitoring plan, and development of monitoring and modeling QAPPs. The second category encompasses the efforts of analyses which explore aspects of the PCB problem in the HSC—linking of spatial facility data for potential contemporary sources and a rough evaluative calculation of air PCB loadings. All of these activities are included in the appendices of this report. The report body serves as sequential overview of yearly activities.

CHAPTER 2 - FISCAL YEAR 2007 ACTIVITIES RECORD

In general the activities of FY 2007 were focused on information gathering and planning activities that will be preparative for later sampling that will occur in FY 2008. A good amount of PCB sampling and analysis of that sampling were previously performed in the dioxin project, but PCB was not the constituent of most emphasis during that time. The PCB TMDL project began in earnest in September 2006, and since that time the activity to understand how to approach the project increased in order to continue the understanding that the dioxin TMDL project had begun.

2.1 LITERATURE REVIEW

The first quarter of the project was spent seeking out scientific article literature and gray literature of fundamental PCB chemistry, transport, fate, toxicity, regulatory history, sampling strategies, and previous studies involving PCBs in similar environments. That information was contained in Quarterly Report 1, and it was not a compilation of all of the literature available but rather a summary of major concepts with some specific studies mentioned throughout. More literature review on specific topics was performed in the second quarter concerning potential PCB contemporary sources. More literature review will be required as the project unfolds, and so updates on old topics and inclusion of new topics will be added to later reports.

2.2 PREVIOUS DATA ANALYSIS

Sampling conducted in summer 2002, fall 2002, and spring 2003 for PCB data was performed in cooperation with dioxin data in the HSC. That dataset sampled surface water, sediment, fish, and crab. It included the following parameters:

1) PCB concentrations for all 209 congeners

2) Sediment Total Organic Carbon (TOC)
3) Fish and crab lipid content

The second quarter of the project was spent further analyzing this dataset from what had been done with it during the dioxin TMDL project. The new analyses were new treatment of ΣPCB concentrations, homolog profile analysis, statistical correlations between TOC and ΣPCB, etc., comparison to other studies, analysis of solid-water partitioning, PCB degradation in sediment, and a closer look at spatial trending. These analyses provided some important conclusions concerning the state of PCBs in the HSC as well as directions of further research and study.

It is not currently thought that more analysis on this dataset alone will need to be performed, but this does not preclude it happening. The intended use at present is

- To serve most as a model calibration data in a water quality model
- To combine with future data to give larger temporal picture of the PCBs in `the HSC

2.3 CONFERENCE CALLS

A series of conference calls were conducted amongst the UH, Parsons, TCEQ project team in the third quarter to coordinate the team with all the activities conducted in the first two quarters and to generate project ideas specifically concerning upcoming sampling on the project. Four main conference calls were conducted, and those minutes are included in Appendix C.

2.4 SAMPLING PLANNING

The goal of the sampling planning, conducted in quarter 3, was to be able to generate three documents in support of sampling: a monitoring plan, a monitoring QAPP, and a modeling QAPP. Much of the work and discussion for the elements in those document occurred in the conference calls and subsequent emails. The monitoring plan was written to be an overview document of general sampling strategy and philosophy. This included a link between the needs of the model as they relate to the determination of how sampling should be performed. The QAPPs were written to exhaustive layouts of monitoring and model practices as they are anticipated to occur. At this point, the monitoring plan has been approved, and the QAPPs are under TCEQ review. Revision will be made on these documents based on comments from reviewers and based on project needs.

2.5 SUPPORTING CALCULATIONS

The conference call discussion helped to generate a list of researchable topics needed for the project. Some of that list was taken care of in the fourth quarter of the yea while some still remain. Two of those tasks were a detailed source analysis using GIS and a preliminary air deposition load calculation to help determine its potential role in the HSC. The source analysis revealed facilities that are most probable as contemporary PCB sources by means of water, air, or landfill disposal. These results helped to provide some potential adjustments for sample station selection as well as support the case for air sampling. The deposition load calculation revealed that from a total PCB load standpoint, air is not likely a major source. Yet it did not preclude the possibility that the presence of certain congeners in the HSC might be explained in this way, especially as it relates to linking those congeners to specific sources. These kinds of calculations will continue during the life of project and will be included in later reports.

APPENDIX A - POTENTIAL SOURCES REPORT

PURPOSE AND APPROACH OF THE REPORT

The sources of PCBs to the HSC, contemporary and historical, are just as important to understanding how to define and implement a TMDL as the assessment of current conditions in the HSC. Historical sources are sometimes difficult to find information on, and they cannot be altered to influence water quality. Contemporary PCB sources are useful to study because through them concentration levels in the Channel can be better explained, and those sources can be adjusted today to improve water quality. In order to gain this understanding, contemporary PCB sources, both proven sources and possible sources, were examined spatially to determine

- Likely pathways of PCB introduction into the HSC,
- Areas of the HSC which may be more strongly influenced by contemporary sources, and
- The validity of current sample location selection in relation to confirmed and probable source locations

The method by which the sourcing was examined was to gather various publicly available data sources, query those sources based on proximity to the HSC and the type of industrial activity at the facility, and finally map the queried locations in reference to Channel geography and sample locations to facilitate analysis. The data sources that were used are shown in Table 1.

Table 1. PCB Source Public Data Retrievals

Data	Data Source	Nature of PCB Source	Release Media	Confirmed / Potential PCB Presence	Confirmed / Potential PCB Release	PCB Potentiality Consideration (Scale 1-3)
Toxic Release Inventory (TRI)	USEPA Envirofacts	Regulated facilities that intentional or accidently release or dispose of PCBs	Wastewater, air, land, or offsite disposal	Confirmed	Confirmed	1
PCB Activity Database System (PADS)	USEPA PADS	Generators, disposers, and transporters of PCBs	Land, water, air	Confirmed	Potential	2
PCB Transformers	USEPA PCB Transformer Database	Users/disposers of PCB transformers as permitted exceptions to the PCB transformer ban	Land, water, air	Confirmed	Potential	2
Air Emissions Inventory	TCEQ 2004 Air Emissions Inventory	Emissions from facilities that could likely coproduce PCBs and emit them as fugitive emissions or out of stacks.	Air	Potential	Potential	3
Wastewater Outfalls	TCEQ NPDES Permit Record	Wastewater outfalls queried by SIC codes known to be potential PCB sources	Wastewater	Potential	Potential	3

It is especially important to note the distinctions between the various data sources in the areas of the actual presence of PCBs and the actual release of those PCBs. TRI releases are the most confirmed facilities for PCB sourcing because PCBs were definitely present at those facilities, and they were definitely released. Those releases may not have made it to the HSC based on the media to which they were released and proximity to the HSC, but the TRI releases carry more weight than the Wastewater Outfalls. These outfalls may not have ever had PCBs at the facility, and it is not clear if those possible PCBs would ever even have been released since PCBs are not regularly monitored in those waste streams. The other sources fall somewhere in between these two extremes.

PCB PUBLIC DATA SOURCE ANALYSES

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This section presents the geospatial analysis of the various source datasets chosen. Much more data went into each map than what could be easily displayed, and that data is included in a large source MS Excel workbook given in this report.

Toxic Release Inventory (TRI) Data

TRI may be easily queried in various forms from the USEPA envirofacts website at http://www.epa.gov/enviro/. It represents a record of facilities regulated within the United States for various contaminants, and in this case PCBs. Any on-site or off-site[*] disposal of PCBs that is known by the facility managers will be reported to the system. In the case of PCBs, major releases in the HSC only included releases by way of air, water, land, and off-site disposal. Note that this is the only data source provided in the report that gives a known release of PCB to the environment and a quantity of that release. Figure 1 presents the results of the TRI facility mapping.

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[*] All off-site disposals reported under TRI are proper disposals that are contained in such a way as to not release PCBs to the ambient environment. They are included in this analysis for the purpose of identifying what facilities are potential PCB producers that could release PCBs by other means.

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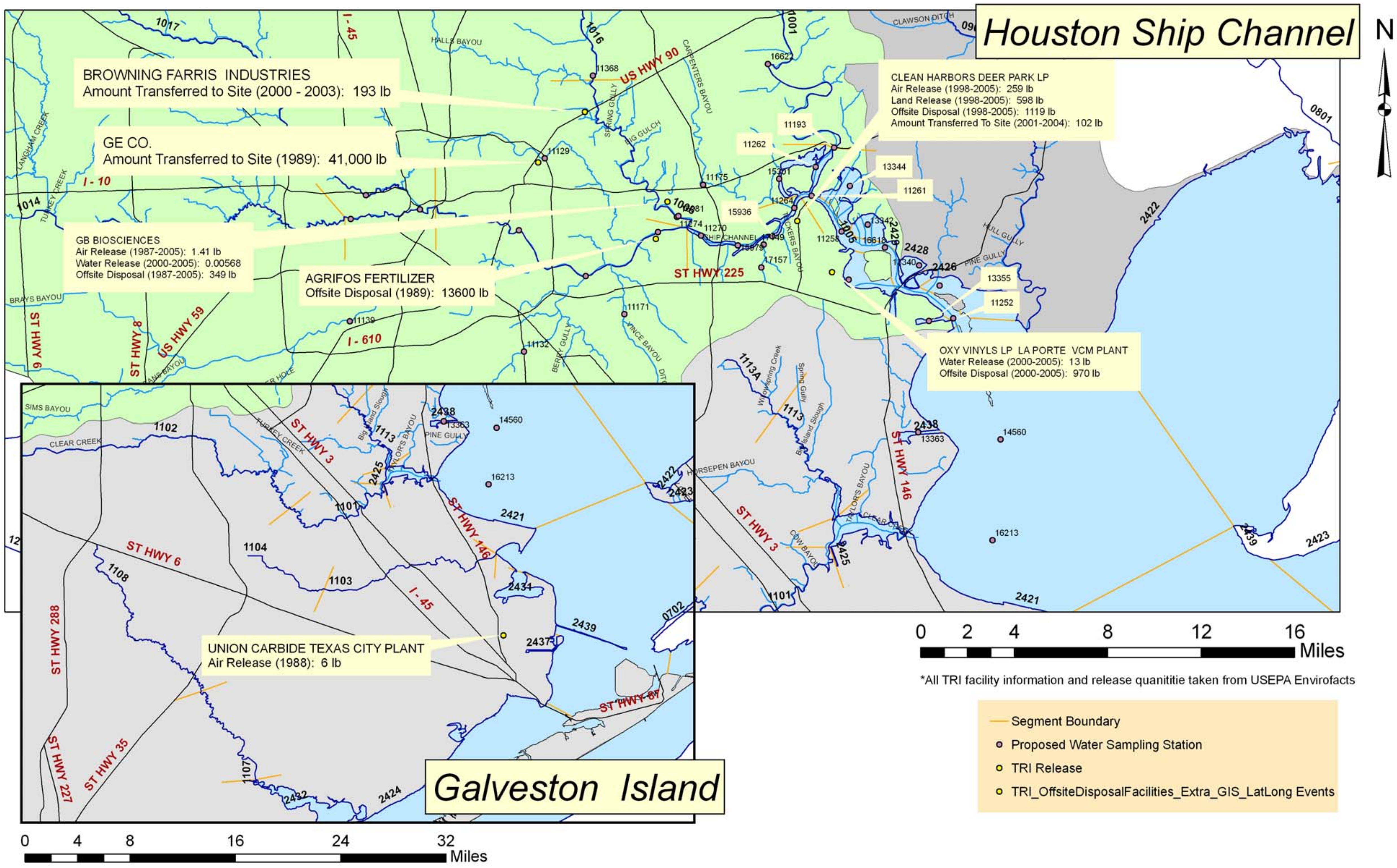

*All TRI facility information and release quanititie taken from USEPA Envirofacts

Figure 1. Toxic Release Inventory (TRI) PCB Releases Compared with Current Sample Locations

Major Points of Note on This Figure

1. Only five facilities exist in the region that have known PCB releases for the last 20 years (2005-2007 assumed mostly negligible), and the total quantities of those releases are quite small (see Table 2). Especially noteworthy is that direct water is the smallest category of release to the HSC at 13 lb.

Table 2. Total recorded TRI releases in all media from 1987-2005 in the HSC area

Pathway	Release Amt (lbs)
Air	267
Water	13
Land	598
Off-site	16,038

2. Only one water release in the system was in the hot spot 1007-1006 segments, and this was a very small release by GBB. GBB did have a significant total production amount of PCBs mainly made up by offsite disposal. This would seem to indicate the possibility of likely sourcing from this point, sourcing which might be incidental, unquantified, and ongoing. GBB may be the only known confirmed PCB producer in 1007-1006 since Agrifos Fertilizer has not had any PCBs reported in any form since 1989.
3. The presence of one land release of a significant PCB quantity by Clean Harbors Deer Park LP would seem to point to the likelihood of groundwater sourcing, at least in the Tuckers Bayou area.
4. The location of sampling stations is justified from these locations as there is a station not far downstream from all locations. The only exception to this would be in the case of Tuckers Bayou that is near Clean Harbors.
5. Known air releases constitute a sizeable amount of PCBs, but it is not clear how much enters the HSC system. Figure 2 presents the TRI air releases in time.

Recent years show less reported releases, which may mean that air has a lower contemporary impact[†].

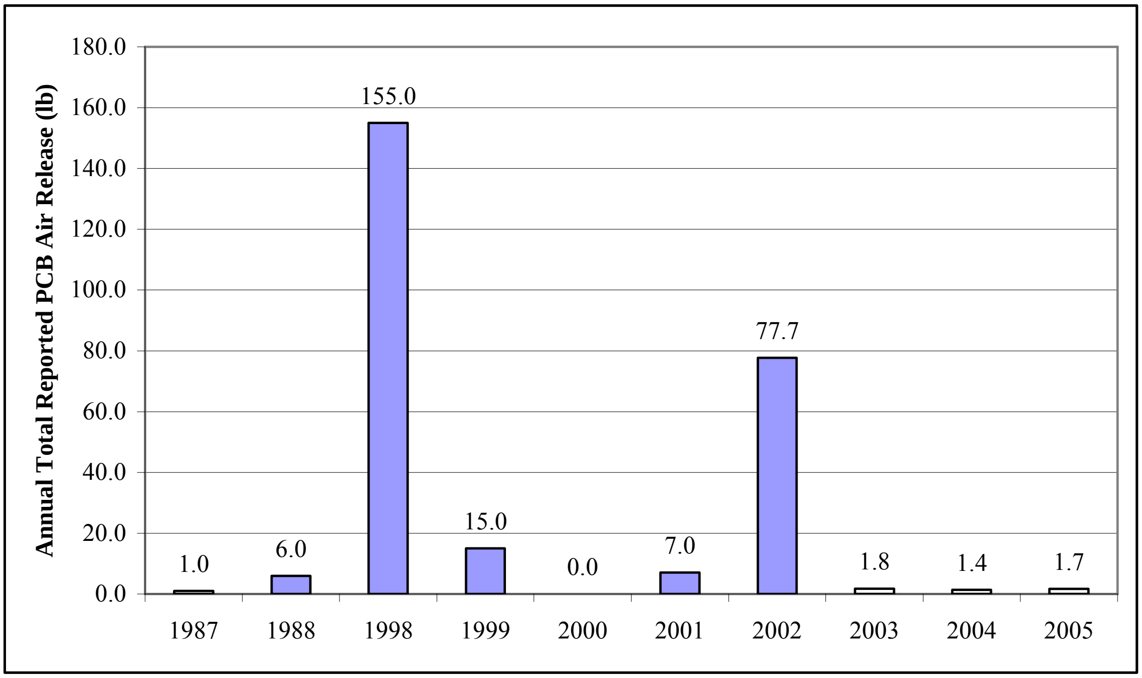

Figure 2. Annual TRI air PCB releases in time

6. Offsite disposal would not normally be a major concern for PCB sourcing since the material is being safely transported to another location. If that location is within the HSC region, however, then this could be significant. There were three facilities that were listed as final disposal locations for PCBs, and they are shown in Table 3. All of those locations except for BFI Gulf West are also included in Figure 1 (BFI Gulf West too far from main area to display).

[†] Air may have a lower impact in more recent years, but it should be remembered that it is likely that most of the air impact from PCBs is likely in the form of unreported and unknown releases in byproduct waste streams, streams which are not usually analyzed for all constituents and therefore not reported to TCEQ.

Table 3. Final offsite PCB disposal locations

Facility	Address	County	City	State	Zip	Disposal Quantity (lbs)
BFI GULF WEST FACILITY	2601 S. JENKINS ROAD	Chambers	Anahuac	TX	77514	15
BROWNING FARRIS INDUSTRIES	11013 OLD BEAUMONT HIGHWAY	Harris	Houston	TX	77078	193
CLEAN HARBORS ENVIRONMENTAL SERVICES	2027 BATTLEGROUND RD	Harris	Deer Park	TX	77536	102.33
GE CO.	8800 WALLISVILLE RD.	Harris	Houston	TX	77029	41000

2.6 PCB Activity Database System (PADS)

The PADS system is a database maintained by the USEPA that monitors the activities of all PCB handlers in the United States. Though PCBs are banned for nearly all uses, activities involving waste and disposal of older PCBs as well as research still require some facilities to use PCBs. These facilities are highly regulated, monitored, and documented. Those facilities found in the PADS were updated and current as of April 2007, and the raw data web access may be found at http://www.epa.gov/pcb/pubs/data.html. Mapping results are shown in Figure 3.

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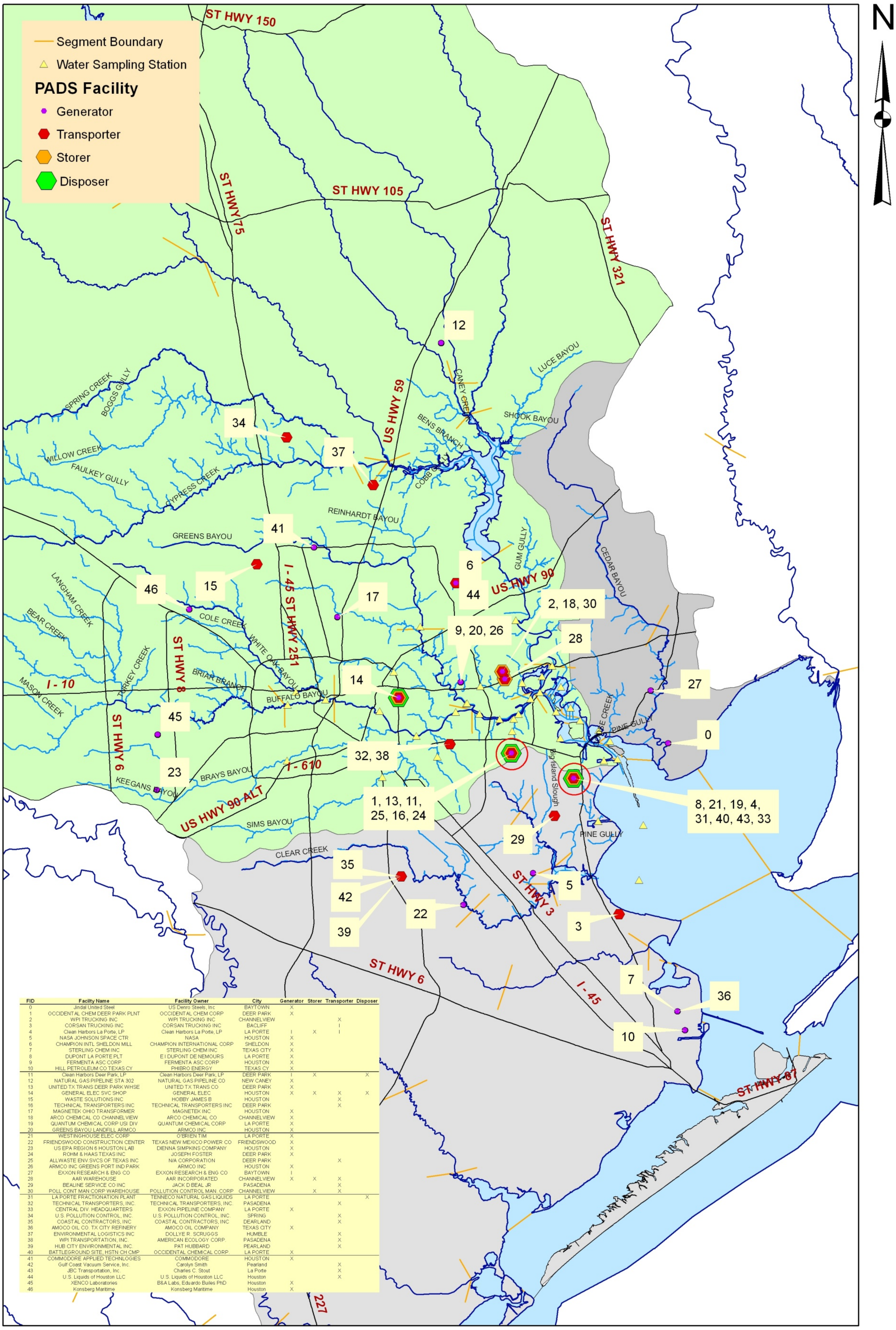


FID	Facilty Name	Facility Owner	City	Generator	Storer	Transporter	Disposer
0	Jindal United Steel	US Denro Steels, Inc	BAYTOWN	X			
1	OCCIDENTAL CHEM DEER PARK PLNT	OCCIDENTAL CHEM CORP	DEER PARK	X			
2	WPI TRUCKING INC	WPI TRUCKING INC	CHANNELVIEW			X	
3	CORSAN TRUCKING INC	CORSAN TRUCKING INC	BACLIFF			I	
4	Clean Harbors La Porte, LP	Clean Harbors La Porte, LP	LA PORTE	I	X	I	
5	NASA JOHNSON SPACE CTR	NASA	HOUSTON	X			
6	CHAMPION INTL SHELDON MILL	CHAMPION INTERNATIONAL CORP	SHELDON	X			
7	STERLING CHEM INC	STERLING CHEM INC	TEXAS CITY	X			
8	DUPONT LA PORTE PLT	E I DUPONT DE NEMOURS	LA PORTE	X			
9	FERMENTA ASC CORP	FERMENTA ASC CORP	HOUSTON	X			
10	HILL PETROLEUM CO TEXAS CY	PHIBRO ENERGY	TEXAS CY	X			
11	Clean Harbors Deer Park, LP	Clean Harbors Deer Park, LP	DEER PARK	I	X		X
12	NATURAL GAS PIPELINE STA 302	NATURAL GAS PIPELINE CO	NEW CANEY	X			
13	UNITED TX TRANS DEER PARK WHSE	UNITED TX TRANS CO	DEER PARK	X			
14	GENERAL ELEC SVC SHOP	GENERAL ELEC	HOUSTON	X	X	X	X
15	WASTE SOLUTIONS INC	HOBBY JAMES B	HOUSTON			X	
16	TECHNICAL TRANSPORTERS INC	TECHNICAL TRANSPORTERS INC	DEER PARK			X	
17	MAGNETEK OHIO TRANSFORMER	MAGNETEK INC	HOUSTON	X			
18	ARCO CHEMICAL CO CHANNELVIEW	ARCO CHEMICAL CO	CHANNELVIEW	X			
19	QUANTUM CHEMICAL CORP USI DIV	QUANTUM CHEMICAL CORP	LA PORTE	X			
20	GREENS BAYOU LANDFILL ARMCO	ARMCO INC	HOUSTON	X			
21	WESTINGHOUSE ELEC CORP	O'BRIEN TIM	LA PORTE	X			
22	FRIENDSWOOD CONSTRUCTION CENTER	TEXAS NEW MEXICO POWER CO	FRIENDSWOOD	X			
23	US EPA REGION 6 HOUSTON LAB	DIENNA SIMPKINS COMPANY	HOUSTON	X			
24	ROHM & HAAS TEXAS INC	JOSEPH FOSTER	DEER PARK	X			
25	ALLWASTE ENV.SVCS OF TEXAS INC	N/A CORPORATION	DEER PARK			X	
26	ARMCO INC GREENS PORT IND PARK	ARMCO INC	HOUSTON	X			
27	EXXON RESEARCH & ENG CO	EXXON RESEARCH & ENG CO	BAYTOWN	I			
28	AAR WAREHOUSE	AAR INCORPORATED	CHANNELVIEW	X	X	X	
29	BEALINE SERVICE CO INC	JACK D BEAL JR	PASADENA			X	
30	POLL CONT MAN CORP WAREHOUSE	POLLUTION CONTROL MAN. CORP	CHANNELVIEW		X	X	
31	LA PORTE FRACTIONATION PLANT	TENNECO NATURAL GAS LIQUIDS	LA PORTE				X
32	TECHNICAL TRANSPORTERS, INC.	TECHNICAL TRANSPORTERS, INC.	PASADENA			X	
33	CENTRAL DIV. HEADQUARTERS	EXXON PIPELINE COMPANY	LA PORTE	X			
34	U.S. POLLUTION CONTROL, INC.	U.S. POLLUTION CONTROL, INC.	SPRING			X	
35	COASTAL CONTRACTORS, INC	COASTAL CONTRACTORS, INC	DEARLAND			X	
36	AMOCO OIL CO. TX CITY REFINERY	AMOCO OIL COMPANY	TEXAS CITY	X			
37	ENVIRONMENTAL LOGISTICS INC	DOLLYE R. SCRUGGS	HUMBLE			X	
38	WPI TRANSPORTATION, INC.	AMERICAN ECOLOGY CORP.	PASADENA			X	
39	HUB CITY ENVIRONMENTAL INC.	PAT HUBBARD	PEARLAND			X	
40	BATTLEGROUND SITE, HSTN CH CMP	OCCIDENTAL CHEMICAL CORP.	LA PORTE	X			
41	COMMODORE APPLIED TECHNLOGIES	COMMODORE	HOUSTON	X			
42	Gulf Coast Vacuum Service, Inc.	Carolyn Smith	Pearland			X	
43	JBC Transportation, Inc.	Charles C. Stout	La Porte			X	
44	U.S. Liquids of Houston LLC	U.S. Liquids of Houston LLC	Houston			X	
45	XENCO Laboratories	B&A Labs, Eduardo Builes PhD	Houston	X			
46	Konsberg Maritime	Konsberg Maritime	Houston	X			

*All location information is from the PADS system maintained by USEPA at http://www.epa.gov/pcb/pubs/data.html.
*Circled facilities are high PADS activity facilities.

Figure 3. PCB Activity Database System (PADS) Facilities

Major Points of Note

1. No quantity information is given in the PADS data.
2. In general a heavier geographic concentration of PADS facilities exists in the near Channel region. In fact 24 of the total 47 facilities (51%) are within 4 miles of the HSC, many of them more on the upstream side. These facilities are shown in Table 4.

Table 4. PADS facilities within 4 miles of the HSC study area.

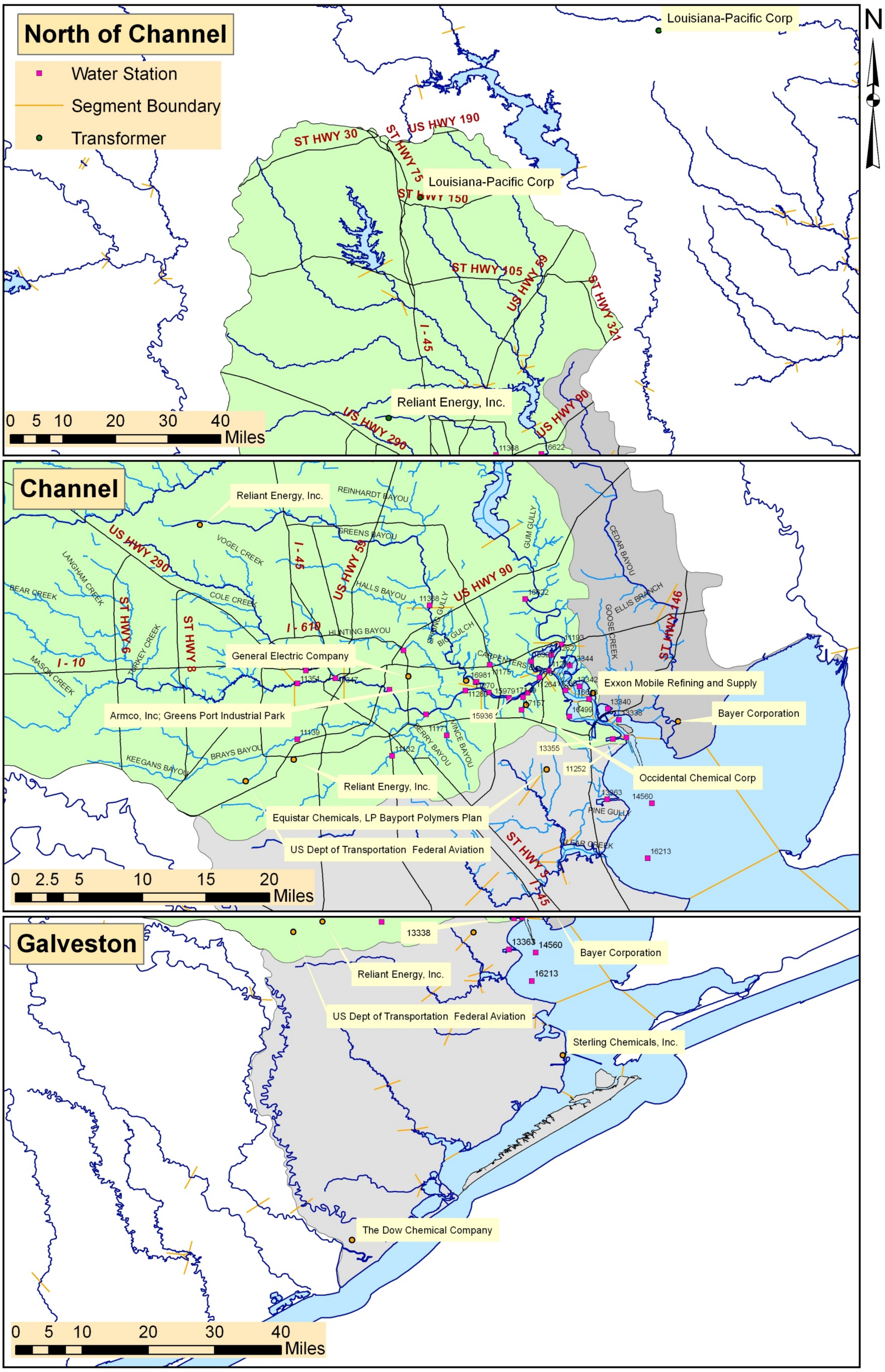
Map Label Number	Facility Name	Facility Owner	City	Generator	Storer	Transporter	Disposer	Likely Receiving Waters
1	OCCIDENTAL CHEM DEER PARK PLNT	OCCIDENTAL CHEM CORP	DEER PARK	X				Patrick Bayou
2	WPI TRUCKING INC	WPI TRUCKING INC	CHANNELVIEW			X		Carpenter Bayou
4	Clean Harbors La Porte, LP	Clean Harbors La Porte, LP	LA PORTE	X	X	X		Little Cedar Bayou
8	DUPONT LA PORTE PLT	E I DUPONT DE NEMOURS	LA PORTE	X				Little Cedar Bayou
9	FERMENTA ASC CORP	FERMENTA ASC CORP	HOUSTON	X				Greens Bayou
11	Clean Harbors Deer Park, LP	Clean Harbors Deer Park, LP	DEER PARK	X	X		X	Patrick Bayou
13	UNITED TX TRANS DEER PARK WHSE	UNITED TX TRANS CO	DEER PARK	X				Patrick Bayou
14	GENERAL ELEC SVC SHOP	GENERAL ELEC	HOUSTON	X	X	X	X	Hunting Bayou
16	TECHNICAL TRANSPORTERS INC	TECHNICAL TRANSPORTERS INC	DEER PARK			X		Patrick Bayou
18	ARCO CHEMICAL CO CHANNELVIEW	ARCO CHEMICAL CO	CHANNELVIEW	X				Carpenter Bayou
19	QUANTUM CHEMICAL CORP USI DIV	QUANTUM CHEMICAL CORP	DEER PARK	X				Little Cedar Bayou
20	GREENS BAYOU LANDFILL ARMCO	ARMCO INC	MIDDLETOWN	X				Greens Bayou
21	WESTINGHOUSE ELEC CORP	O'BRIEN TIM	LA PORTE	X				Little Cedar Bayou
24	ROHM & HAAS TEXAS INC	JOSEPH FOSTER	DEER PARK	X				Patrick Bayou
25	ALLWASTE ENV.SVCS OF TEXAS INC	N/A CORPORATION	DEER PARK			X		Patrick Bayou
26	ARMCO INC GREENS PORT IND PARK	ARMCO INC	HOUSTON	X				Greens Bayou
28	AAR WAREHOUSE	AAR INCORPORATED	HOUSTON	X	X	X		Carpenter Bayou
30	POLL CONT MAN CORP WAREHOUSE	POLLUTION CONTROL MAN. CORP	HOUSTON		X	X		Carpenter Bayou
31	LA PORTE FRACTIONATION PLANT	TENNECO NATURAL GAS LIQUIDS	LA PORTE				X	Little Cedar Bayou
32	TECHNICAL TRANSPORTERS, INC.	TECHNICAL TRANSPORTERS, INC.	DEER PARK			X		Little Vince Bayou
33	CENTRAL DIV. HEADQUARTERS	EXXON PIPELINE COMPANY	LA PORTE	X				Little Cedar Bayou
38	WPI TRANSPORTATION, INC.	AMERICAN ECOLOGY CORP.	PASADENA			X		Little Vince Bayou
40	BATTLEGROUND SITE, HSTN CH CMP	OCCIDENTAL CHEMICAL CORP.	DEER PARK	X				Little Cedar Bayou
43	JBC Transportation, Inc.	Charles C. Stout	Houston			X		Little Cedar Bayou

3. One facility in upper Halls Bayou, Magnetek Ohio Transformer, is a PCB generator facility that is not extremely close to the Channel area, but nonetheless could be an upstream source to the Channel. Comodore Applied Technologies is a similar situation, but it is located in upper Greens Bayou. The planned water sampling station at the Greens-Halls confluence (station 11368) should yield a good picture of the possible impact from these two facilities. A higher PCB reading at this station could validate further upstream investigation.

4. One facility, Konsberg Maritime (46 in the figure) is in upper White Oak Bayou. No sampling is currently planned close to this facility. The stations in this area of the Channel are planned for the purpose of background PCB assessment anyway, but a higher level of PCB in these upper reaches might be explained by the presence of this PCB generator.
5. Two facility locations (circled on the figure) both located south of the channel have a high number of PADS facilities at one location with all manner of PCB activities at those locations. Neither of these facilities are located at ostensibly on segment locations, but the nature of these facilities (e.g. chemical plants, chemical transporters, electric companies, pipelines) suggests that wastewater outfalls would be associated here. In the case of the near Patrick Bayou location, PCB found there might be explained from these facilities though pinpointing an exact source is admittedly difficult without sampling directly from an outfall.
6. There are two PADS generator facilities along Cedar Bayou in segment 901. Currently a TBD water station is planned for this bayou. The location for this sample should take these facilities into consideration.
7. Generally, the water sampling stations planned should give fair estimate of the effects of on segment PADS facilities. Many facilities, however, are not clearly on any segment. The impact of these facilities may prove to be more difficult to assess.

PCB Transformers Facilities

The PCB transformer facilities are those facilities that have greater than 500 ppm of PCB dielectric. These transformers have been registered and approved for continued use by USEPA. The information may be found at http://www.epa.gov/pcb/pubs/data.html. Locations of the geographically relevant facilities are shown in Figure 4.



*All transformer locations represent transformers that are still permitted to use PCBs. The information was taken from the EPA PCB Transformer Registration System located at http://www.epa.gov/pcb/pubs/data.html.

Figure 4. PCB transformers near the HSC

Points of Note

1. Most of the transformer facilities are distant from the study area and are thus not likely sources to the HSC.
2. Table 5 presents a list of facilities that might influence the HSC and an explanation for their inclusion in that list.

Table 5. Likely PCB Transformers to the HSC

Count	Facility Name	Location Description	No. of Transformers	Reason for Likely Source Consideration
1	US Dept of Transportation Federal Aviation	Willow Water Hole, an upper tributary of Brays Bayou	2	HSC tributary location
2	T.H. Wharton Generating Station - Reliant Energy	Upper Greens Bayou	3	HSC tributary location
3	Armco Inc., Greens Port Industrial Park	Greens Bayou-HSC Confluence	2	HSC location
4	Occidental Chemical Corp	Patrick Bayou	4	HSC tributary location and high number of transformers
5	Exxon Mobil Refining and Supply	Lower Scott Bay	1	HSC location
6	Bayer Corporation	Lower Cedar Bayou	33	Cedar Bayou location, extremely high number of transformers

3. Segment 1006 is already known to have high PCB concentrations. The Greens Port Industrial Park at Greens Bayou and the Occidental Chemical site at Patrick Bayou may be a contemporary contributor to PCB concentration in this zone. Sampling near these points is planned.
4. The Exxon Mobil site at Scott Bay is an interesting locale for a PCB transformer point since concentrations at that point were not exceedingly high. The amount of water here that could cause dilution might mask any effect of PCB sourcing. Sample station 16618 should give a view of any contemporary sourcing.
5. The transformer facility at Bayer Corporation should be considered in the choice of the Cedar Bayou sample station. Previous sediment sampling conducted at a station upstream of this location showed a low concentration. Since water sampling has never been conducted in this Bayou, and the previous station was upstream of this facility containing 44 transformers, it may be wise to put the

TDB station downstream of Bayer Corporation. In order for this to occur, however, it would need to be determined if the intake area for the cooling water pumps would prevent outfall wastewater from being sampled in the bayou. More information is needed to determine if this is currently an issue at Bayer.

6. The other two sites shown in Table 5 are upstream tributary stations that are outside of the modeling perspective (since only facilities with direct HSC discharges are considered independently), but the presence of these facilities may help explain tributary inflow to channel concentrations.

2.7 Air Emissions Inventory

The TCEQ conducts a yearly emissions inventory from air permitted waste stacks in an effort to monitor particular constituents. PCB is not one of those constituents, but, as was the case with Wastewater Outfalls, SIC Code querying can be used to grab particular facilities. The facilities are mapped in Figure 5.

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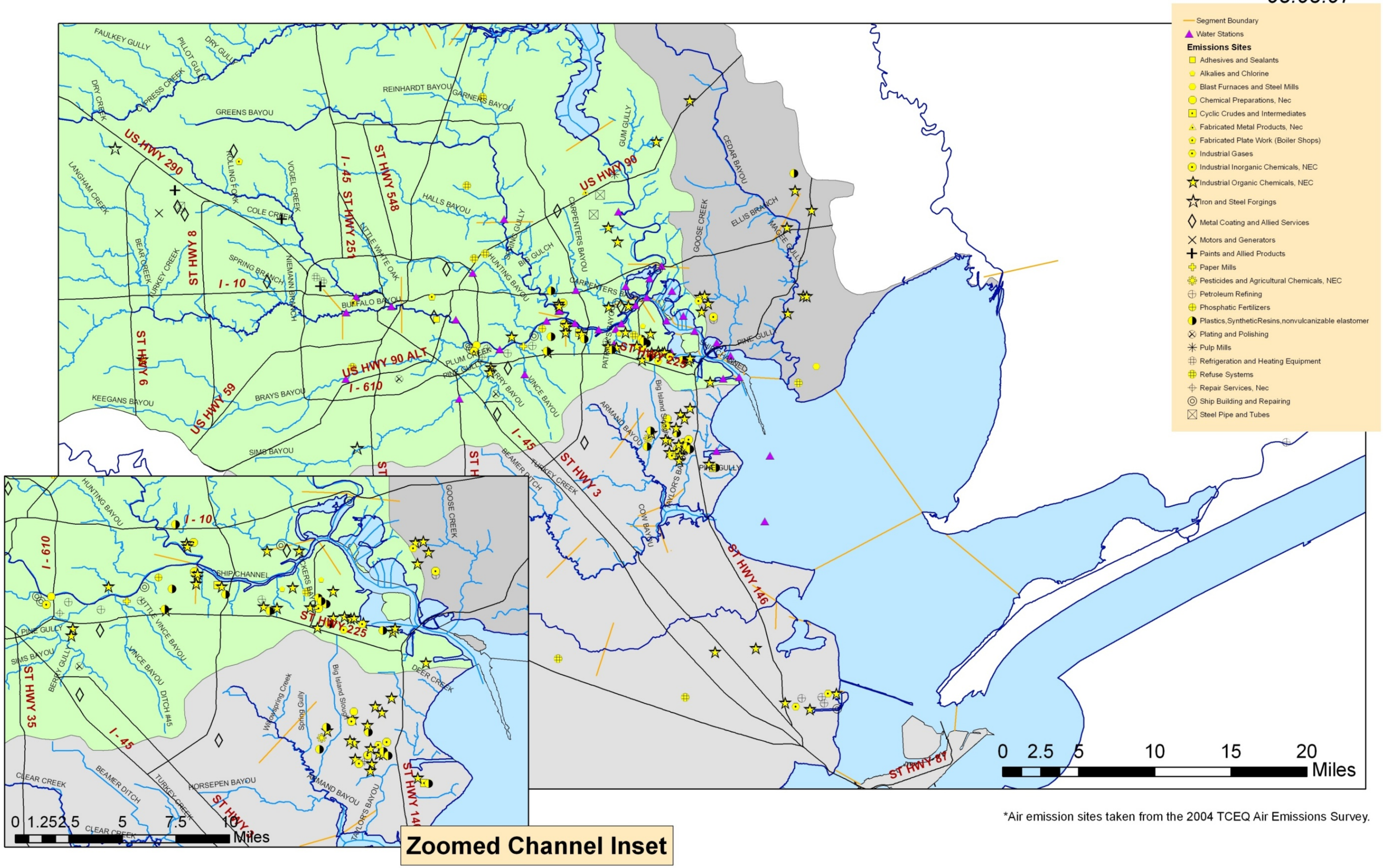

*Air emission sites taken from the 2004 TCEQ Air Emissions Survey.

Figure 5. Air emission sites queried by SIC code

Points of Note

1. Potential PCB air emitters are dispersed throughout all of the HSC study area. Since there is no PCB stack testing, it is difficult to truly state that a particular facility or region is contributing much to the HSC. The information would be more directly useful if one, some, or all of the following were true:
    - A few particular facility types were found from literature or experience to definitively coproduce PCBs.
    - A particular region of the Channel had higher PCB concentrations in water that could be explained only by depositional loads. Then the facilities of that region would be more suspect.
    - Peculiar PCB congeners were found that were known to be markers of particular industry types, industry types found in the air emissions of the HSC study area
2. The highest emission density of facilities is along the HSC, and the Bayport Channel. The Bayport Channel water samples did not show particularly high PCB concentrations in the 2002-2003 sampling (0.57 ng/L and 2.08 ng/L for two stations, 13589 and 13363, averaged over the three events). Thus, it does not seem like a localized air impact made a noticeable difference in concentrations in this case.
3. Particular SIC code frequencies for the facilities shown in Figure 5 are given in Table 6. The highest frequency categories were Industrial Organic Chemicals, Plastics, Synthetic Resins, and Nonvulcanizable Elastomers, and Metal Coating and Allied Services.[‡]

[‡] The highest frequency of facilities may have nothing to do with actual PCB impact. If a high number a particular facility exists but that facility in fact rarely produces PCBs or only in small quantities, then it is not a real concern. By the same token, a low frequency of a particular facility type that is known to produce larger quantities of coproduct PCBs should be considered more significantly. The frequency count is just one method of understanding this data.

Table 6. SIC code frequencies among emission stacks

SIC Description	No of Stacks
Adhesives and Sealants	1
Alkalies and Chlorine	2
Blast Furnaces and Steel Mills	1
Chemical Preparations, Nec	2
Cyclic Crudes and Intermediates	2
Fabricated Metal Products, Nec	1
Fabricated Plate Work (Boiler Shops)	3
Industrial Gases	7
Industrial Inorganic Chemicals, NEC	9
Industrial Organic Chemicals, NEC	*61*
Iron and Steel Forgings	2
Metal Coating and Allied Services	*11*
Motors and Generators	1
Paints and Allied Products	3
Paper Mills	1
Pesticides and Agricultural Chemicals, NEC	1
Petroleum Refining	9
Phosphatic Fertilizers	1
Plastics,SyntheticResins,nonvulcanizable elastomer	*17*
Plating and Polishing	2
Pulp Mills	1
Refrigeration and Heating Equipment	2
Refuse Systems	9
Repair Services, Nec	2
Ship Building and Repairing	6
Steel Pipe and Tubes	3

*Most numerous types presented in *italics.*

4. In general air emissions, are not as localizable as many of the other data sets presented here since they can travel greater distances in the atmosphere. Also these emissions facilities have not been confirmed as PCB coproducers but as potentials for PCBs. Nonetheless, it is difficult to ignore the amount of possibility for air sourcing in light of the number of facilities present that might produce PCBs and the current paucity of understanding concerning how big a role air emissions play in contemporary PCB sourcing.

2.8 TCEQ Wastewater Outfalls

TCEQ wastewater outfalls were selected from large statewide outfall database according to SIC codes deemed to be likely involved in PCB coproduction. SIC codes chosen for the query were taken from a variety of literature sources given in the Appendix. One note of caution with the data for wastewater outfalls is that of the approximately 1000 wastewater outfalls in the HSC region (Galveston, Chambers, Harris counties), only about a third of them could actually be queried by SIC code, which means that **only about 330 of the 1000 could actually be considered in this analysis**. The rest did not have an SIC code by which to query. Figure 6 presents the result of this analysis.

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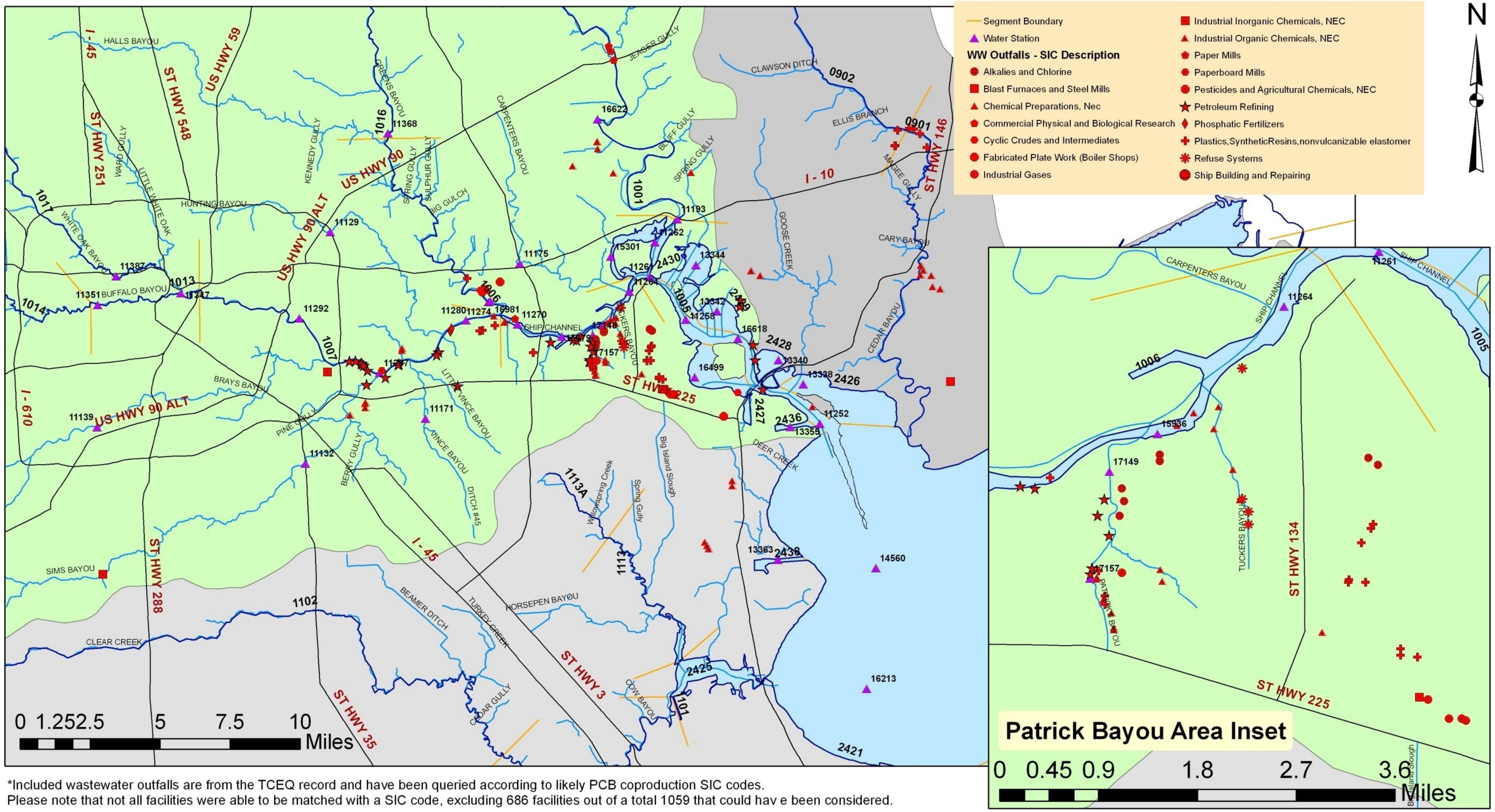
08.02.07



*Included wastewater outfalls are from the TCEQ record and have been queried according to likely PCB coproduction SIC codes.
Please note that not all facilities were able to be matched with a SIC code, excluding 686 facilities out of a total 1059 that could hav e been considered.

Figure 6. Wastewater outfalls as selected by potential PCB coproduction SIC code

Points of Note

1. Too many outfalls exist to look at them individually at this point. It is more valuable to consider the overall picture without greater concentration information and knowledge of each individual outfall.
2. Three main sections appear to exist along the HSC. Moving from upstream to downstream, there is a section at the Sims Bayou-HSC confluence, a section at the Greens Bayou confluence, and a section at Patrick Bayou on the HSC.
3. Statistics for the chosen SIC codes are given in Table 7. It is seen that the three most numerous types of potential PCB coproducers are Industrial Organic Chemicals, Petroleum Refining, and Plastics, Synthetics, Resins, Nonvulcanizable Elastomer. These highest frequency categories are not surprising when considering that the major industry along the HSC is petrochemical.

Table 7. SIC code frequencies among WW outfalls

SIC Description	**No of Outfalls**
Alkalies and Chlorine	7
Blast Furnaces and Steel Mills	1
Chemical Preparations, Nec	1
Commercial Physical and Biological Research	4
Cyclic Crudes and Intermediates	7
Fabricated Plate Work (Boiler Shops)	1
Industrial Gases	6
Industrial Inorganic Chemicals, NEC	4
Industrial Organic Chemicals, NEC	*50*
Paper Mills	4
Paperboard Mills	1
Pesticides and Agricultural Chemicals, NEC	1
Petroleum Refining	*46*
Phosphatic Fertilizers	2
Plastics,SyntheticResins,nonvulcanizable elastomer	*31*
Refuse Systems	4
Ship Building and Repairing	5

*Most numerous types presented in *italics.*

4. The major conclusion from the analysis of wastewater is mainly what was already intuitive-that the most industrialized parts of the Channel, which are also the most PCB-laden parts of the Channel, have the greatest number of potential PCB

coproduction wastewater outfalls. Furthermore, most of the outfalls that drop directly into the HSC are near a sampling point to the extent possible.

5. Two other important areas in regard to the WW outfalls are the upper San Jacinto River, which has a paper mill facility and some industrial organics facilities, and upper Cedar Bayou, which has several Plastics, Synthetic Resins, and Nonvulcanizable Elastomer outfalls. For the San Jacinto zone, the 16622 station may be able to gauge the effect of these outfalls if needed. In the case of Cedar Bayou, the TBD station will NOT be able to gauge these outfalls since it is supposed to be a non-tidal sample location. The tidal influence of Cedar Bayou goes all the way up past the I-10 bridge to the 0901 segment boundary, upstream of the facilities being considered.

Combined Analysis

In an effort to look for broad spatial patterning, all of the different datasets were combined into a single map in Figure 7.

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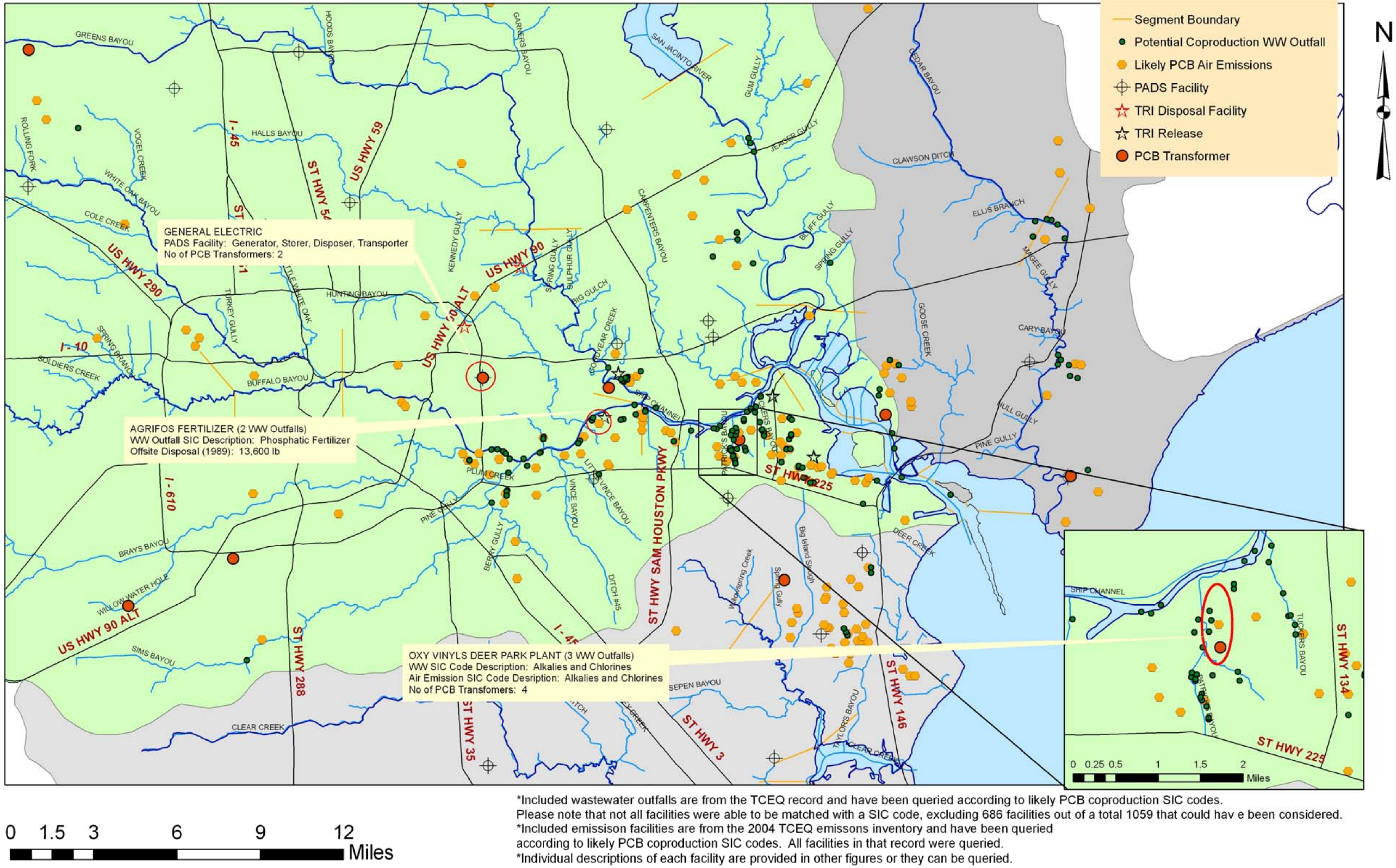

GENERAL ELECTRIC
PADS Facility: Generator, Storer, Disposer, Transporter
No of PCB Transformers: 2

AGRIFOS FERTILIZER (2 WW Outfalls)
WW Outfall SIC Description: Phosphatic Fertilizer
Offsite Disposal (1989): 13,600 lb

OXY VINYLS DEER PARK PLANT (3 WW Outfalls)
WW SIC Code Description: Alkalies and Chlorines
Air Emission SIC Code Desription: Alkalies and Chlorines
No of PCB Transfomers: 4

*Included wastewater outfalls are from the TCEQ record and have been queried according to likely PCB coproduction SIC codes.
Please note that not all facilities were able to be matched with a SIC code, excluding 686 facilities out of a total 1059 that could hav e been considered.
*Included emissison facilities are from the 2004 TCEQ emissons inventory and have been queried
according to likely PCB coproduction SIC codes. All facilities in that record were queried.
*Individual descriptions of each facility are provided in other figures or they can be queried.

Figure 7. Master Potential Facility Source Map

Points of Note

1. Overall trends show a concentration of facilities along the main body of the Channel all the way upstream to the Sims Bayou-HSC confluence.
2. The San Jacinto River in the 2002-2003 sampling showed lower concentrations of PCB in water and sediment, though given the history of dioxin contamination in that area, it is still suspect for PCB introduction to the Channel. If it is a pathway of downstream PCB load, then there are not very many facilities along that segment that could, at least in this analysis, be explanatory sources. Then either most of the PCB sourcing is historical or one or two facilities can explain a contemporary load.
3. The most valuable part of this analysis is the use of geo-matching to see where one particular facility shows up in multiple datasets. The figure shows three facilities that match in this way—General Electric, Agrifos Fertilizer, and Oxy Vinyls Deer Park. General Electric has shown activity in many different PADS categories and harbors PCB transformers, but this facility is not on a direct tributary to the Channel as far as can be told from the figure. Agrifos Fertilizer has disposed of large quantities of PCBs in the past and is in an industry that potentially coproduces PCBs. This industry, phosphatic fertilizers, may be more than potential in light of the definite presence of PCBs here in 1989. More research into the literature would be required to determine this. And Oxy Vinyls with a location on Patrick Bayou, yearly TRI PCB releases to both water and offsite, four PCB transformers, and coproductive potential in both water and air would seem to be a contemporary source if not for the fact that the plant there has been closed. This facility would need to be analyzed in more of a historical sense. These three facilities together represent the most likely PCB sources contemporarily and in recent history under this analysis and should be considered first in sampling and in later data analysis.

MAJOR CONCLUSIONS

1. Confirmed water release in the last 20 years of HSC record keeping amount to only 13 lb. Other pathways have confirmed amounts that may or may not have ever made their way to the Channel. Any other information in regards to contemporary sourcing from specific facilities is speculative though worth considering.
2. The only confirmed TRI PCB water releases on the record were at GB Bioscience along Greens Bayou and Oxy Vinyls La Porte VCM Plant.
3. Air emission into the Channel air space has been confirmed in recent years and especially in large quantities as recently as 2002. The locational proximity of potential PCB coproduction facilities and that amount of those facilities should be considered in conceptualizing PCB loadings from air. Other than the two facilities in recent years that have confirmed PCB air releases, localizing air PCBs without facility specific sampling will be difficult especially when considering how little is still currently known about potential PCB coproduction.
4. All datasets show a high concentration of actual PCB housing, releasing, and potentially releasing facilities along the main section of the HSC. Historical sourcing from sediments seems to be a likely explanation for much of the high PCB concentrations found in 2002-2003, but at the same time the high concentration of potential PCB facilities should not be ignored or considered a geographical coincidence.
5. In general, the current water sampling plan is adequate to gauge the effects of the sources considered in this analysis. The only point of further consideration is where the TBD station along Cedar Bayou should be. At points along this segment, even far upstream points, PADS facilities, and potential coproduction facilities exist. The location of this station would serve the project well if it could

gauge the effects of these facilities, especially the one PADS facility and the PCB transformer facility. It would also be helpful to consider sampling at a station in Tuckers Bayou since there are eight potential coproduction facilities along its banks.

6. Three facilities from the combined facility map appeared in many of the datasets, and two facilities from the TRI dataset appeared as consistent PCB water releasers. These facilities listed in Table 8 are what are considered by the methods and limitations of this analysis to be most probable contemporary PCB sources in the Channel. Caveats to this prioritizing are that there is not necessarily enough information about all of the facilities to eliminate them, and it is also likely that there are facilities not covered in any of the geographic analyses that could be sources.

Table 8. Highly likely PCB contemporary/recent source facilities

Facility Name	Facility Type	Approximate Location	Reason for PCB Priority
GB Biosciences	Agricultural Chemicals	Just upstream of Greens Bayou-HSC confluence	Confirmed PCB water release
Oxy Vinyls LP La Porte VCM Plant	Organic Chemicals	Western edge of San Jacinto Bay	Confirmed PCB water release
General Electric Service Shop	Power Generation, Power Equipment Service and Disposal	0.9 miles south of I-10 and the East Loop	Multiple PADS listing and houses 2 PCB transformers
Oxy Vinyls Deer Park Plant (closed)	Organic Chemicals	Upper Patrick Bayou	Potential historical WW and Air PCB coproducers, 4 PCB transformers
Agrifos Fertilizer	Fertilizers	Midway between Hunting and Greens Bayous on the HSC (south side)	Large offsite PCB disposal in 1989, potential WW coproducer

EXCEL SOURCE FILE

The Excel source file is attached electronically at the end of the report.

APPENDIX B - AIR LOAD CALCULATION

INTRODUCTION

For the Houston Ship Channel (HSC) PCB TMDL project it is necessary to at some level consider every load type that could possibly deliver PCBs to the system. Some of these load types are clearly major contributors to the total load in the project while other load types are questionably significant. One of these questionably significant loads is air deposition both wet and dry sources. Previous analysis on the 2002-2003 PCB dataset showed that air might be a source of particular PCB congeners that could not be explained in any other way such as PCB-209. Park et al. (2001) determined that PCB-209 was present in air samples in the HSC, and so air study might be valuable for two reasons.

1. Total load determination
2. Source of particular PCB congeners and possibly particular facilities

The particular emphasis in this calculation is on a preliminary estimated total load determination from air sources.

APPROACH

The approach taken for the calculation was the following:

1. **Deposition Rate Determination**: These rates were taken directly from Park et al. (2001) and applied to the HSC. Certain assumptions were made in the use of these rates, and these will be discussed later.
2. **Segment Areas**: In order to use the deposition rates from Park et al., it was necessary to get an area of the HSC, side bays, San Jacinto River, and upper Galveston Bay. The areas were determined using GIS as well as some measurements of stream widths using the deep draft channel survey (USACE, 2007). Table B-1 shows these final areas.

Table B-1. Surface Water Quality Monitoring (SWQM) areas calculated by GIS

SWQM Segment	Segment Name	Area (sq miles)
1007	Upper HSC	2.77
1006	Lower HSC (not including Greens Bayou)	0.89
1005	San Jac Tidal	4.63
1001	SJR	2.35
2421	Upper Galveston Bay	108.00
2426	Tabbs Bay	4.00
2427	San Jacinto Bay	2.00
2428	Black Duck Bay	1.00
2429	Scott Bay	2.00
2430	Burnett Bay	3.00
2436	Barbours Cut	0.00
2438	Bayport Channel	1.00

3. Gather Water PCB Concentrations: PCB water concentrations were obtained from the 2002-2003 PCB HSC sampling dataset. They were time averaged per sample location, and then those averages were averaged per region of the HSC. A region was not defined on the basis of SWQM segments alone but was actually broader than that. Table shows the regions and their respective concentrations.
4. Determine Flows in HSC for In-Stream Load Calculation: It was decided that flows from the HSC RMA2 hydrodynamic model should be used for the calculation. Though, the model was used for the dioxin TMDL, the hydrodynamics should be the same for PCBs, and the PCB water concentrations under item 3 covered the same time period as the model. These flows were time-averaged for the RMA2 2002-2005 three year run. The resultant time-averaged flows were specific to particular WASP model segments. These WASP model segments flows were then averaged together to get a representative flow for the entire SWQM segment. Flows were not used for the side bays as calculating the side bay in-stream load seemed like more detail than what is needed for this preliminary calculation. The flows for the various segments used are shown in Table B-2.

Table B-2. SWQM segment tPCB concentration and flows used

SWQM Segment	Average PCB Concentration ng/L	Averaged Flow m^3/s
1007	3.20	38.60
1006	6.14	38.60
1005	1.89	176.08
1001	1.12	135.26

5. Final Calculation: Depositional loads and in-stream loads were calculated using all of the previously mentioned datasets on an annual basis.

CHAPTER 3 RESULTS AND DISCUSSION

Table shows the various loads calculated by deposition and in-stream for the four main HSC segments. Further visual display of these results is given in Figure .

Table B-3. Resultant values of the deposition calculation

Segment	Area m^2	Average tPCB Concentration ng/L	Total Deposition Load kg/yr	In-Stream Load kg/yr	Deposition to In-stream Load Comparison %
1007	7.16E+06	3.20	0.035	3.89	0.89%
1006	3.31E+06	6.14	0.016	7.48	0.15%
1005	3.11E+07	1.89	0.151	10.49	0.56%
1001	6.09E+06	1.12	0.030	4.80	0.62%
Total*	4.76E+07	-	1.755	26.66	6.21%

*The total given for the Total Deposition Load is a total of all segments in the HSC Region including the side bays and Galveston Bay (i.e. the total shown is greater than the total of the four segments). For simplicity, the in-stream loads were not calculated for the other segments, and these in-stream loads were not thought to be as significant as the four that are given. The value of the % ratios in the table is to determine the significance of deposition. If the deposition is not very significant using just the four in-stream loads shown here, then it will not be significant if all of them are considered together either.

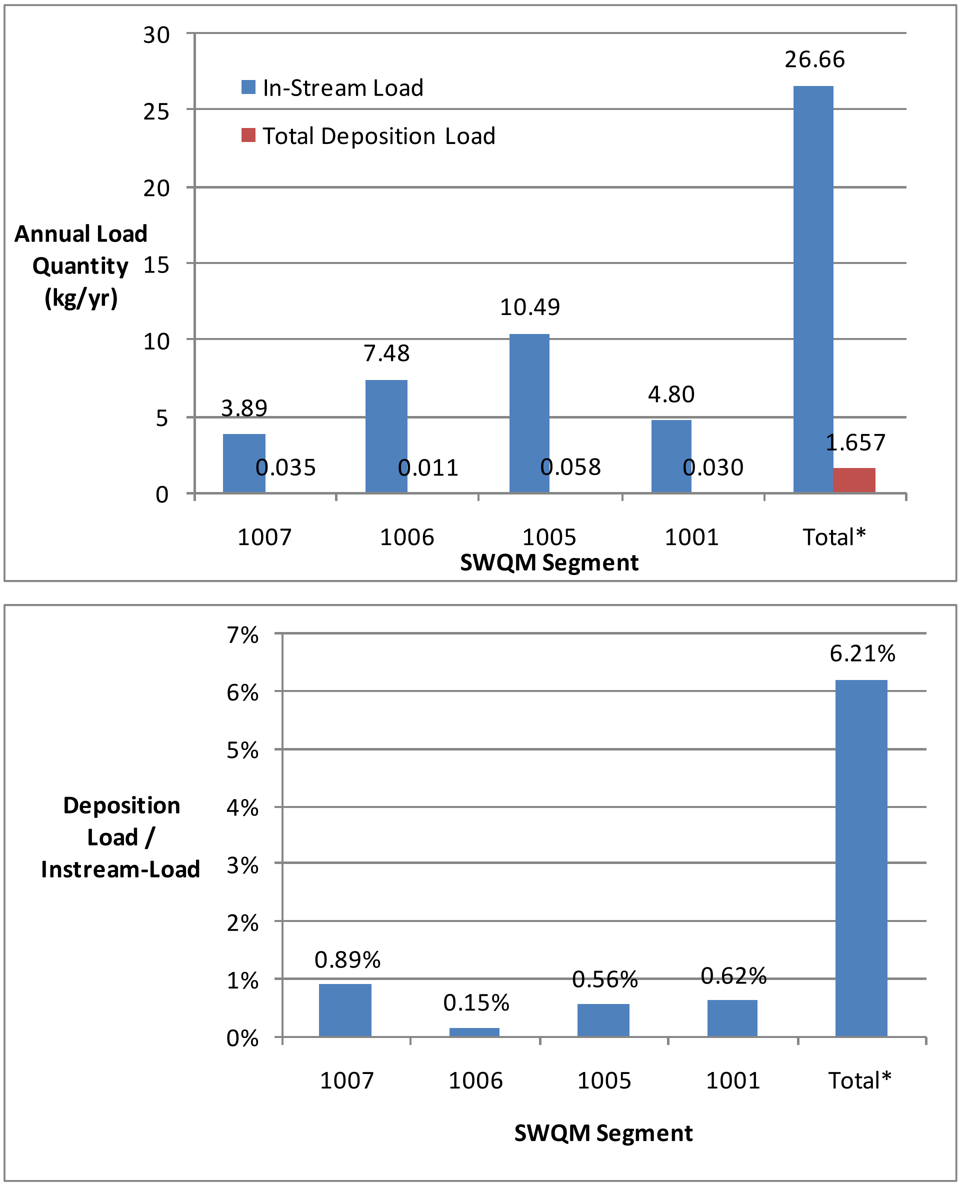

Figure B-1. Deposition to in-stream PCB load comparisons

The figure shows that the depositional load would appear to be the largest relative to the local in-stream load in segment 1007. This is not too surprising since this segment also has one of the largest area of all of the segments considered.

In general, all segments compared were at a low percentage of depositional load relative to in-stream load. The total percentage given in Table B-3 and Figure B-1 is a comparison of all of the in-stream segments loads to the total depositional load. The in-stream segment loads included only segments 1005, 1006, 1007, and 1001 while the total depositional load includes all segments. Thus, the comparison is slightly boosted in the total category towards deposition. Even in that boosting, however, the ratio of deposition to in-stream is still under 10%.

CONCLUSIONS AND FURTHER CONSIDERATIONS

The foremost conclusion from this calculation is that under the conditions used the depositional load estimation is not very large relative to the entire in-stream loads on a per segment comparison. A 10% cutoff of significance seems reasonable given the sizes of the other loads that will be measured more directly in the project: sediment, upstream flows, and point sources.

If this estimation is accurate enough to the real situation in the HSC, it would then seem reasonable on the basis of total depositional load alone to not seek out more detailed measurements of PCBs in air. There are, however, a few considerations about such a conclusion.

1. Need for Source Identification: Since air samples may help explain the presence of unusual congeners or give clues to source facilities, it may be still be useful albeit perhaps in a limited way (e.g. in a locally intensive study or in a very low density over the channel area)
2. Further Calculations: The calculations performed in this report, were thorough but not ultimate. The dry deposition rate, as explained and assessed in Park et al. (2001), is determined by local water concentration. This is problematic to this calculation for two reasons. One reason is that the time that Park et al. conducted their study was different from time of the concentrations being used in the HSC PCB TMDL project. The other, and potentially more significant reason, is that the concentrations used by Park et al. were from Galveston Bay, where the PCB concentrations are much lower in water than what is typically found in the HSC region. The dry deposition rate would certainly be higher than what is used here. Thus, deposition may be more significant than what this simple calculation would show.
3. Side Bays: Perhaps if side bays were considered more directly, then deposition might be significant in those places. The areas of those bays are much larger than the flowing channel region. Also, those bays are generally thought of to be more quiescent. So the flows may be lower than the main channel while at the same time having an area

increase. This creates a potential for a larger deposition contribution in those segments considered by themselves. The total system depositional contribution would still likely be under 10%.

Recommendations at this point would be to rectify the considerations just presented by doing further calculation as well as to do more research into the air contribution of other water bodies seen in the literature to see if it was a significant load in those places. These results do not seem strong enough to completely exclude some measure of air sampling.

REFERENCE

Park, J.S., Wade, T.L., Sweet, S., 2001. Atmospheric deposition of organochlorine contaminants to Galveston Bay, Texas. Atmos. Environ. 35, 3315-3324. USACE, 2007. Galveston District Surveys. U.S. Army Corps of Engineers, Houston.

APPENDIX C - CONFERENCE CALL MINUTES

04.03.07

OVERVIEW

Subject: Initiate sampling talks on the project

Members: Monica, Randy, Hanadi, Larry, and Nathan (secretary)

Time: 9:15-10:45 AM

TASK LIST

1. Re-look at PCB data using zero ND instead of ½. (Nathan)
2. Cost estimate for all congener methods. (Monica)
3. Research into species to be sampled. (Parsons)
4. Re-look at PCB data using OC normalization for sed. (Nathan)
5. Water segment sampling schedule. (Nathan)
6. Sediment sampling schedule. (Parsons)
7. Historical Aroclor PCB datasets, especially sediment. (UH)
8. Dioxin stakeholder participation. (Larry)

MINUTES

Conference Calls: We will try to have one every week for the next 4 weeks

PCB Congener Set

- Larry said that the standards of required regulatory PCB analysis are being prepared, but it is not yet clear what they will be.

- Ann Strahl is running the PCB Advisory Group that is attempting to help revise TRRP rules on PCB analysis. See minutes of a meeting http://www.tceq.state.tx.us/assets/public/remediation/pcb/agenda011206.pdf.
- Decided that we want to get as much knowledge on the situation as possible for the money. To do that, it is best to compare the different costs of analysis by congener set used and by laboratory that would run the method. Monica was tasked with getting these cost comparisons together for the following congener sets
    - 43 congener set used by the Health Dept in a Nov 2005 Fissue Tissue Advisory at Alison Creek
    - 18 NOAA NST congeners
    - 18 NOAA EPA congeners
    - 209 complete congener set

General Comments on Previous PCB Dataset of 2002-2003

- Randy requested recompilation of PCB totals using non-detects of zero as opposed to the half NDs that were used in order to see how much difference there is. Nathan was tasked with this.
- Hanadi suggested that crab may not be a useful species with which to assess health risk. Larry furthered the idea in saying that crab is not in the advisory and that crab is not a huge health problem based on previous data (data may be reviewed in Quarterly Report 2)
- Randy and Kirk agree to recommend species of crab and fish for the project, and trout was suggested as another option.
- Hanadi and UH agreed to set up the data transfer for old and new data that is generated.

Sediment Sampling – Tributaries

- Hanadi suggested the importance of looking at tributary sediments for the potential transport to the channel, especially for tribs in 1006.
- OC-normalized sediment concentrations were brought up as an issue. The 2002-2003 sediment data in Quart Rep 2 was not presented that way. Nathan will redo it with the normalization in order see how trends and conclusions change.
- Point also brought up that OC could be analyzed in sediment beds as well as in suspended particles. Need to decide what kinds of OC we will need.
- Randy mentioned that he had looked at Patrick Bayou in another project already.
- Dredging of Greens Bayou was discussed as a frequent occurrence. Randy noted that dredging records for any of these tribs is available if needed.

Water Sampling

- All agree that water sampling needs to be done.
- The issue of tributary water sampling was discussed. Thoughts on tribs were
  - Upstream sampling would be good to avoid tidal influence, and this could also provide a way to do "headwater" sampling to get ambient runoff
  - Municipal plants upstream on Green Bayou need to be considered.
  - 1006 and 1007 would be the most useful tribs to sample
- "Background" PCB concentrations will be needed.
  - Tribs could be used for this
  - Dioxin project used upstream Buffalo Bayou concentrations for background
  - Larry suggested that we may need to discern between normal city runoff background and industrial PCB background.
- The issue of higher side bay concentration in 1005 was brought up.
  - Explanations could be differing mud texture here and/or equilibrium mass transfer conditions existing here versus other parts in 1005. (Nathan/Hanadi suggestion)
  - Larry suggest hydraulic separation happens here that make the side bays sediment sinks
  - Volatilization may be a factor here or other parts of the channel as evidence by the Park et al. (2001) study. The fact that PCB-209 was found in both the air the Park air study and in our sampling may suggest a depositional link.
- SJR Waste Pits – We are waiting to see if we will be allowed to sample at that location as possible source of PCBs.
- Action Item – Make a schedule of segments that need sampling. Nathan tasked with this.
- Randy suggested the possibility that rationale for water sampling allow for more limited sampling if we don't need real data for everything.

Sediment Sampling – Overall Rationale

- Temporal understanding of sediment PCB concentrations is not as important as what is happening right now, especially in the hot spot segments.
- Hanadi suggested that blanket sampling not be done.
- Nathan suggested sediment coring – suggestion made that it be used mainly as an additional detailed analysis for hot spots
- Action Item – Parsons will suggest sediment segments to sample
- Randy suggested that we look at historical sediment sampling data. UH will look into doing this.

Sources Discussion

- Issue framed in terms of who is and who was discharging PCBs

- Facilities that produce PCBs for release would probably be of two kinds: historical effluents and coproduction/byproduction contemporary dischargers.
- Randy suggested that storm water runoff from plant sites may be a source
- Larry suggested asking the stakeholders of the dioxin group what their thoughts on likely sources would be
- It was decided that next meeting would deal more with source discussion

Keeping up standards

- Water quality standard is currently in terms of Aroclors. It will not remain that way therefore we do everything at some level of congener analysis.
- Need to look into groundwater standards to see how PCBs are treated there. Larry noted that cleanup and action levels are available now in groundwater.

Final Thoughts

- Keep up a goal to understand through sampling and planning what our important PCB transport pathways are.
- Keep in mind the model to be used. Choice and application of model needs to be able to help us do what needs to be done.
- Randy said that we need both PS and NPS for certain on sources.
- Decided that Nathan would set up a shared folder or shared method of getting out and revising project information.

04.12.07

OVERVIEW

Subject: Sources, Stormwater Sampling, and Water Sampling Methods

Members: Dean, Burdorf, Randy, Monica, Hanadi, Larry, and Nathan (secretary)

Time: 1:50 – 2:50 PM

TASK LIST

1. Find probable SIC codes for PCB WW discharges. (Burdorf)
2. Look into the details of sludge reporting on PCBs. (Dean)
3. Report on SIC codes for potential air PCB discharges. (Nathan)
4. Find a database that has information on grandfathered PCB users that may have been exempt from regulation. (UH)
5. Compile a list of the types of sources of PCBs for later comparison with SIC codes and activities in HSC. (UH)
6. Confirm that TCEQ definitely does NOT sample for PCBs in standard air emission inventories. (UH)

7. Find useful PCB discharge information from TRI reports. (Larry)
8. Find the national stormwater sampling database used previously for dioxins. (Monica)
9. Stormwater runoff information from literature. (Nathan)

MINUTES

Reported on previous meeting minutes. No objections to them noted.

Work Strategy: Get through all of the various issues on the conference calls and then report on the results from the various assignments that are given once everyone has had time to review all of the documentation from the tasks.

Sources

Historical Sources

The main questions on the historical sources are:

- What data is available?
- Out of the available data, which of it is relevant?

Possible historical sources include wastewater, groundwater, paper mills, disposal facilities, etc. There were two main ways of historical source searching that were discussed:

1. The compiling of SIC codes that would have released PCBs as WW.
2. Historical sludge reporting. Dean will look into how difficult this will be to do.

Other misc. historical sources discussed:

- GW – Not known if it has been sampled much yet
- Air SIC codes – Nathan will report on this

Current Sources

Ways to find current sources:

- If not much data is available, sampling is all that we can do to get this information.
- Grandfathered PCB users
- Sludge sampling

- Process wastewater (possible that this is commingled with stormwater after treatment, possible creation of PCBs in process streams)
- Link SIC codes with what is found in the HSC. Need to find these codes.

Stormwater Sampling

Runoff sources include: leaky transformers, transformer disposal yards, normal urban runoff

Runoff sampling strategy to take: Sample USGS gauges to get runoff at those points, and then downstream runoff measurement need to be taken separately. And collect background runoff concentrations/loads.

A stormwater database may exist. Monica will try to find it and report back.

Conclusions: For right now, we need to gather more information before deciding how the runoff sampling will go and then if that sampling will occur in the first year of sampling or later.

High Volume Sampling

Discussion on SPMDs. It was decided that these might be useful for some specific applications, but in general the type of information gathered by them is not useful enough.

High-Volume Sampling was the best option as far as we can tell. Issues discussed with this sampling include what volumes should be used and what the pumping rates should be. Initial sampling will be required to get this information.

Analysis Discussion

More will be discussed in the next meeting, but Monica reported that the 209 congener list would cost the same as a list of 43. The prices have gone down on these analyses.

Larry brought up that the EPA may now require that only NELAC labs are to be used to analyze samples. A list of these labs is available.

End

Larry mentioned a recent PCB sources talk that will be given at a conference on May 2nd. The topics for next week should be the air issue, physical/chemical processes, modeling, and potentially more talk on analysis methods.

04.20.07

OVERVIEW

Subject: TMDL Approach, Modeling, Air Sampling, Physical/Chemical Processes
Members: Dean, Burdorf, Randy, Hanadi, Larry, and Nathan (secretary)
Time: 10:07 – 11:02 AM

TASK LIST

1. Comparison of BAF data found in previous PCB work with standard BAFs. (Unassigned)
2. Air relevancy calculation: a look at probable HSC fluxes using literature data from Park et al. (2001). (Unassigned)
3. Querying physical/chemical parameters from CD database. (Unassigned)
4. Data gathering from NRDA Colonial Pipeline and the Gulf Coast Resource Center at LSU. (Hanadi)
5. Supply the G. Fred Lee report to the group. (Larry)
6. Compilation of total task list, who is assigned the tasks, and the deadline for submission to the team. (Hanadi)

MINUTES

TMDL Approach

Larry supplied a potential approach for establishing the TMDL in a more efficient manner. The main points of the plan included.

- A focus on sediment and sediment source pathways
- Runoff sampling analyzing the dissolved/suspended phase split so that suspended only phase can be measured
- Limitation of sampling point sources
- Motivation behind the idea that TCEQ would like to get TMDL targets defined quicker
- The modeling approach would be similar to dioxins with the two model set

Response to this plan was met with the following comments:

- At least a few point sources should be sampled in order to give some real data to the values that would be used in a model.
- Sludge data research/sampling could be performed to get more information on point sources, but the details of how to do it were tabled for later.

Modeling

In regards to modeling, Larry's TMDL strategy was assumed to the tact on modeling for now.

The two issues related to modeling that were discussed were:

1. Media Concentration Modeled: It was thought that it is still best to model the water concentration as was done in the dioxin TMDL.
2. BAFs: BAFs are useful to the overall TMDL analysis but not to the modeling part itself. The final model result in water could be transformed using a range of BAFs, which might produce an ultimate TMDL range rather than a specific number.

Air Sampling

<u>Unknowns in Mass Balance</u>: Air was sampled in dioxin study to get loads, and the mass balance remainder was taken as sediment load. Air, sediment loads, or a conglomeration of processes could be submitted as the mass balance remainder to an IP group.

Air Direction: The question may be is air a source or sink of PCBs, and then more specifically, for which congeners and in what locations.

- Dean offered an air sparging method to most definitively determine the flux direction and magnitude of air volatilization/deposition, but this method is time-consuming.
- A better way to deal with the problem in a practical sense was to use literature values and possibly a small number of air samples to make a good guess on the air component.
- Ultimately, the specifics of the issue will be dealt with later and can be changed as needed even during the sampling itself according to the needed model inputs.

Physical/Chemical Parameters

A large literature value database of parameters will be used for all the parameters needed for the model. Only if these prove problematic would site-specific parameters be used.

Other Datasets Available

1. G. Fred Lee Report: Introduces the possibility of measuring TPH as a correlative parameter for PCBs.
2. NRDA Colonial Pipeline Data: SJR dataset that may involve some PCB sampling
3. Gulf Coast Hazardous Resource Center: LSU group that may have some done PCB sampling

Current Project Direction

Get all assignments that have been laid out so far completed so that everyone can look at all of the information to collectively draft a project plan.

Budgeting Discussion: Idea was brought out that a multi-year plan should be developed to eliminate unnecessary administrative efforts. The approach does not assume that money will be available for every FY in the plan.

04.30.07

OVERVIEW

Subject: Sampling Station Plans/Task Updates

Members: Burdorf, Randy, Monica, Hanadi, Larry, and Nathan (secretary)

Time: 11:00 AM – 12:40 PM

TASK LIST

1) Make comments on proposed stations put out by (1) Parsons and (2) UH. Get back to responsible parties before Friday, May 4th. (Parsons-UH swap)
2) Submit final station selections for water, sediment, and fish samples by 5/4. (Parsons,UH)
3) Distribute UH sampling maps to Parsons. (Nathan)
4) Finish historical SWQM data analysis. Submit results. Use results to make sure that station selections make sense temporally. (Parsons)
5) PCB BAF analysis results from 2002-2003 data sent to team. (Nathan)
6) Colonial pipeline information gathering and reporting. (Hanadi)
7) Look at previous RMA2 hydrodynamic modeling for dioxins to see what sampling needs in terms of flow or other measurements might be required to make it better for this project. (Monica)
8) Generate a standard sample acquisition and analysis cost. (Monica)

MINUTES

Review Planning Document

Hanadi went through the tasks that had been laid out up to this point. Important points from that discussion include:

- The dioxin hydrodynamic model should be used for the project since it has already been well-developed.
- Reminder to resolve SWQM historical data in the sampling plan.

- Decide which tasks had been completed and which required more time.

Parsons Sampling Plan Walkthrough

Important points of the sampling strategy include:

- Use the trib sampling only for water in non-tidally influenced sections.
- Strived to sample only the largest tribs to be representative of the greater trib behavior.
- Less sampling required than a new project because the hydrodynamic model already exists, and previous PCB sample data can be used to calibrate and validate the model.

Issues were brought up that would help to fix some of the weaknesses in the dioxin model. These were the lack of data in the lower boundary of 1001 (the lower branches of SJR that are in the upper reaches of 1005), flow calibration difficulties at certain points in the system, and vertical profiling in some parts of the channel (potentially solved by vertical composite water sample).

Details of the species selection for fish were given with the general idea being that trout was most desirable but catfish will be much easier to find and will suffice if needed. Samples would not be composited between species before sent to the lab, but they may be averaged in data analysis.

UH Sampling Plan Walkthrough

Important points of the UH sampling strategy were discussed:

- Water analysis beyond PCB determination using DOC, POC, and possibly TPH.
- Three types of water sampling, colder ambient, warm ambient, and wet sampling.
- In general, more sampling was recommended in order to characterize the change in concentration in 5 years time and to characterize some areas which previously had few samples in them.

The discussion included thoughts on the difficulty of sampling in Patrick’s Bayou superfund area, potential PCB sources to 1005 that might need a station to address, the need for TPH analysis, and a better understanding of sampling frequency.

Costing

Monica presented the following approximate costs for sample analysis by matrix.

Matrix	**Analysis Cost**
Tissue	$450
Sediment	$450
Water	$550
XAD Resin	$675
GFFs	$670

The point was made to include an approximate 10% markup to account for duplicates and blanks.

Effluent Sampling Discussion

- Only two facilities along the channel report any PCB releases
- Effluent sampling could approximate the effluent load by sampling a half dozen facilities

APPENDIX D - PROJECT PLAN

Total Maximum Daily Loads for PCBs
In the Houston Ship Channel

Contract No. 582-6-70860

Work Order No. 582-6-70860-13

Rev2 Project Plan, Monitoring Plan and
3rd Quarterly Report

Prepared by
University of Houston
Parsons Water&Infrastructure

Principal Investigators
Hanadi Rifai
Randy Palachek

PREPARED IN COOPERATION WITH THE
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY AND
U.S. ENVIRONMENTAL PROTECTION AGENCY

The preparation of this report was financed through grants from the U.S. Environmental Protection Agency through the Texas Commission on Environmental Quality

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July 2007

Introduction

Polychlorinated biphenyls (PCBs) are widespread organic contaminants that are environmentally persistent and can be harmful to human health even at low concentrations. A major route of exposure for PCBs worldwide is through food consumption, and this route is especially significant in seafood. The discovery of PCBs in seafood tissue has led the Texas Department of State Health Services to issue seafood consumption advisories, and some of these advisories have been issued for the Houston Ship Channel (HSC). Two specific advisories have been issued recently for all finfish species based on concentrations of PCBs, organochlorine pesticides, and dioxins. ADV-20 was issued in October 2001 and includes the HSC upstream of the Lynchburg Ferry crossing and all contiguous waters, including the San Jacinto River Tidal below the U.S. Highway 90 bridge. ADV-28 was issued in January 2005 for Upper Galveston Bay (UGB) and the HSC and all contiguous waters north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. These two advisories represent a large surface water system for which TMDLs need to be developed and implemented.

The scope of the TMDL PCB project includes project administration, participation in stakeholder involvement, development of a project plan, development of a monitoring plan, and preparation of sampling and modeling Quality Assurance Project Plans (QAPPs).

This document is the draft PCB Project Plan and also serves as the third quarterly report for the project. The Project Plan includes the following elements:

- Compilation and Assessment of Existing Data
- Selection of Modeling Perspective and Tools
- Designing the Monitoring Plan
- Preparation of Cost Estimates for the Project Plan

These elements of the Project Plan will be described in more detail below:

Compilation and Assessment of Existing Data. A detailed literature review was undertaken in the first quarter of FY07 and the findings were summarized in the first quarterly report for the fiscal year (see Appendix A).

A compilation and analysis of data that were gathered by the PCB project team during summer 2002, fall 2002, and spring 2003 was prepared during the second quarter of the current fiscal year and presented in Chapter 2 of the second quarterly report. The analysis was updated during the third quarter and the updated Chapter 2 is included in Appendix B.

In addition, historical data from the SWQM database were downloaded and analyzed. The results from the analysis are included in Appendix C.

The PCB data gathered in summer 2002, fall 2002, and spring 2003 were analyzed during WO7 of the dioxin TMDL project to estimate bioaccumulation factors for PCBs in the Channel. The report is included for reference in Appendix D.

Based on the analyses completed and described in Appendices B and C, data gaps were identified and were incorporated into the monitoring plan design as will be discussed later in this document.

Lastly, the literature was also reviewed to determine potential sources of PCB into waterways and in particular into the Houston Ship Channel. The results from the literature review were summarized in the 1st quarterly report for FY07 (see Appendix A). Additional source information that has been gathered during the second and third quarters is being compiled and analyzed to develop a database of potential historical and current PCB sources to the Channel.

Selection of Modeling Perspective and Tools. The project team is currently developing an RMA2-WASP7 model for the Channel as well as a loading spreadsheet for the dioxin TMDL project. A similar approach will be used for the PCB TMDL. The RMA2-WASP7 models will be modified to represent sources and processes that are appropriate for PCBs.

It is noted, however, that while the models used for PCBs are the same as those for dioxins, the strategy guiding the PCB TMDL project is different. The strategy for PCBs is centered on the concept of defining PCB loading at the mouths of tributaries draining into the Houston Ship Channel and limiting the sources assessment to those sources that directly discharge into the Channel. PCB loading from runoff will be estimated for adjacent areas and tidal segments of the Channel that are not part of the tributary watersheds. Runoff from potential industrial sources and other facilities that directly discharge to the Channel will also be quantified.

Design Monitoring Plan. The literature review, analysis of historical and SWQM data, along with source data gathering and analyses were used to develop the following draft monitoring plan for PCBs:

Geographic Scope. In total, the consumption advisories for PCBs cover all or part of designated water quality segments 0901 Cedar Bayou Tidal, 1001 San Jacinto River Tidal, 1005 Houston Ship Channel/San Jacinto River Tidal, 1006 Houston Ship Channel Tidal, 1007 Houston Ship Channel/Buffalo Bayou Tidal, 2430 Burnett Bay, 2429 Scott Bay, 2428 Black Duck Bay, 2427 San Jacinto Bay, 2426 Tabbs Bay, 2436 Barbours Cut, 2438 Bayport Channel, and 2421 Upper Galveston Bay. All parts of those segments that are covered by the PCB consumption advisories will comprise the project area.

Media. Sediment, water, and fish would be sampled. Crab would not be sampled since previous data from summer, fall 2002, and spring 2003 indicated that levels were below standards for crabs in all segments. Air sampling and air deposition studies may be undertaken based on the results from the source assessment work that is on going at this time.

Target tissue species. Wherever possible, two fish species will be sampled at a single location: speckled seatrout (the species included in the advisory) and catfish (preferably hardhead). Each sample will consist of edible tissue from 3-5 individuals.

Congeners. All 209 PCB congeners will be quantified across the various media.

Parameters other than PCBs. For sediment: TOC, TPH. For water: TSS, DOC, POC, TPH, Salinity, Specific Conductivity, and Temperature. For fish: percent lipids.

Flow sampling will be undertaken at selected stations: 11347 (Buffalo Bayou at Main Street), 16873 (Patrick Bayou Upstream of WWTP), 11200 (San Jacinto River Tidal at US90), 11175 (or TBD99 – Upstream Carpenters Bayou) and 11272 (Carpenters Bayou at Sheldon Rd).

Data Gaps. A number of data gaps have been identified thus far and these have motivated some of the specifics of the monitoring plan:

- Boundary concentrations for the RMA2-WASP7 will be required so PCBs in water should be quantified at the non-tidal portions of the major tributaries preferably close to USGS gages that are used in the model.
- For deep channel locations, PCB concentrations in water would be measured as a vertical composite or as the average of deep and shallow samples for more meaningful comparisons to the two-dimensional vertically averaged RMA2-WASP7 modeling results.
- Flow measurements would be undertaken concurrently with water sample collection at the upstream boundaries (non-tidal segments) to allow estimation of the PCB loads entering the channel.
- To better estimate partitioning coefficients in WASP7, POC will be measured in addition to DOC.

Data Objectives. The objectives for sampling for PCBs for the three media in the Channel include:

- Address the data gaps listed above
- Provide a current snapshot of PCB concentrations in sediment, fish and water in the Channel.
- Minimize the number of sampled stations with non-detect concentrations.
- Maximize the number of sampled stations that have been sampled previously to obtain a temporal understanding of PCB behavior in the system.
- Sample stations that have historically exhibited high concentrations in any medium.
- Maximize the number of samples where all three media are sampled concurrently to allow comparisons among the media.
- Consider the presence of potential sources in station selection.
- Water concentrations at the mouth of major tributaries (non-tidal) would be measured to allow load estimation (using flow from USGS gage for the trib). The concentrations would be measured in dry and wet-weather conditions.

- Ambient concentrations in the channel for the three media would be sampled during warm and cold weather to assess temperature effects, if any.
- Undertake extensive localized surveys in sediment and water in areas that exhibit high PCB concentrations and in areas that might be experiencing precipitation of suspended or dissolved materials due to the fresh/saline interface between tidal and non-tidal conditions.

Sampling Sites. The selected sampling sites and frequency of sampling are presented in Table 1. Figure 1 shows the sediment and tissue station locations and Figure 2 shows the water sampling locations.

Intensive Surveys. In addition to the proposed sediment, tissue and water sampling proposed in Table 1, intensive sediment surveys in 1001 and 1006 in the vicinity of the observed hot spots in the 2002-03 dataset would be undertaken prior to water sampling to pinpoint the longitudinal extent of the hot spots and/or potential localized sources of PCBs. The exact location and number of samples have not yet been determined but the total number of samples is expected to be less than 40 from these intensive surveys.

Sediment studies to evaluate the validity of the high settling rates downstream of the hot spots in 1006. The project team is evaluating possible strategies for addressing this issue that arose during model development in the dioxin project. Possible studies include sediment traps, sediment samplers, grain size analysis of existing data and trends from upstream to downstream, obtaining and analyzing recent data from Corps of Engineers on sedimentation and maintenance/dredging, measuring TSS concentrations to determine areas of high deposition, measuring turbidity profiles to identify areas where re-suspension might be occurring, analyzing biomarkers such as sediment lipid content, isotropic C/N ratios, or chlorphyll-a, and laboratory studies of salinity effects on coagulation of colloids using HSC waters. Literature studies as well as the Superfund proposed efforts in Patrick Bayou will be reviewed to support the development of a final strategy. Dr. Kyle Strom from UH will assist in developing this component of the study.

Sources Sampling. Up to 20 facilities that directly discharge to the Channel would be sampled for PCB in their discharge as well as in their runoff.

Water Sample Volume. Sampled volumes will be between 200 and 400 L depending on historical levels.

Laboratory Methods. PCBs will be quantified as individual congeners using USEPA Method 1668A.

Detection Limits. Detection limits vary among congeners and among samples of a given media due to the presence of interferences.

Table 2 provides a summary of expected detection limit ranges that are based upon laboratory reports for the PCB samples collected in the HSC in 2002 and 2003.

Table 2. Method Detection Limits (MDL) by Media

Media	Units	MDL Range	Reporting Limit
Tissue	ng/g	0.011-0.067	0.06
Dissolved	ng	0.02-1	0.3
	ng/L[a]	0.0001-0.005	0.002
Suspended	ng	0.02-1	0.3
	ng/L[a]	0.0001-0.005	0.002
Bottom sediment	ng/g	0.05-0.25	0.25

[a] Based on a minimum sample size of 200 L

Equipment. The equipment previously used in the dioxin project will be used primarily for the PCB project. An equipment inventory analysis is currently underway to identify equipment needs for the PCB TMDL.

Data Management Roles and Personnel. Dr. Hanadi Rifai and Randy Palachek will be the project principal investigators from UH and Parsons, respectively. Monica Suarez, Dr. Kirk Dean, Jim Patek, Curt Burdorf and Nathan Howell will be key project scientists and engineers that will implement the Project Plan. Personnel from both UH and Parsons will be utilized to complete the Project Plan. Data management will be primarily a UH responsibility.

Quality Control Roles and Personnel. Field activities and quality control activities will be primarily a Parsons responsibility.

Public Participation. Members of the dioxin stakeholder group have been invited to serve as a technical advisory group for the PCB project. A number of public meetings will be held throughout the duration of the PCB project to encourage participation from the public (no more than twice per yr).

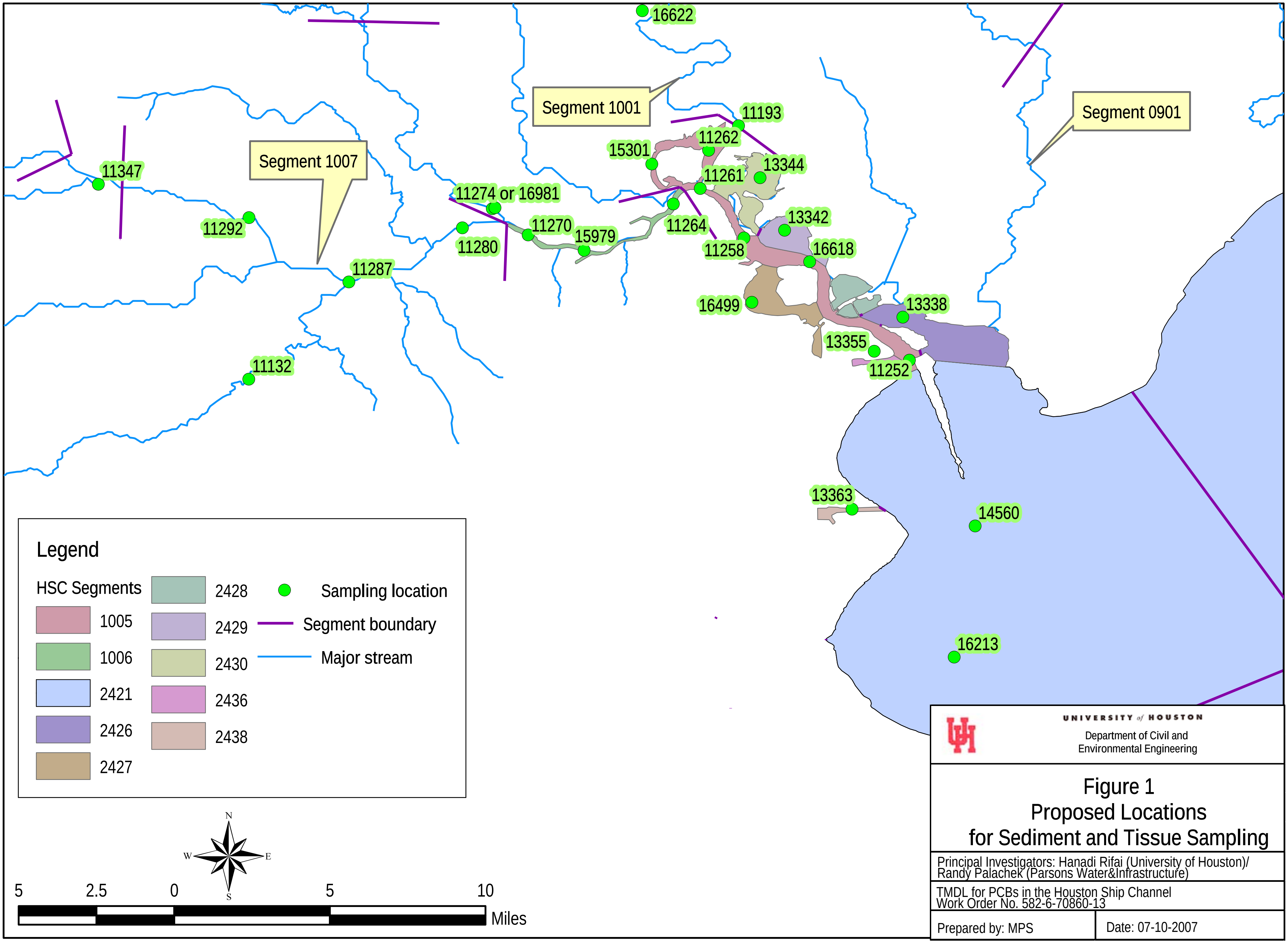
Timeline. The project plan calls for completing the PCB TMDL by FY 2010 as follows:

FY 2007 – Project Plan, Monitoring Plan and QAPP preparation
FY 2008 – Sampling and Analysis
FY 2009 – Sampling, Analysis and Modeling
FY 2010 – Estimating TMDL and Writing Report

Budget. The budget for the PCB Project Plan is $1,391,500. Details are shown below in Table 3.

Table 3. PCB Project Plan Budget

Category	**Cost**
Monitoring in Table 1	
Labor	$500,000
Analytical	$300,000
Supplies	$60,000
Intensive Surveys	$50,000
Sediment Settling Rate	$100,000
Modeling	$100,000
Public Meetings	$30,000
Load Allocation Spreadsheet	$20,000
TMDL Report	$50,000
Subtotal	**$1,210,000**
OH (15%)	**$181,500**
TOTAL	**$1,391,500**



UNIVERSITY of HOUSTON
Department of Civil and Environmental Engineering

Figure 1
Proposed Locations for Sediment and Tissue Sampling

Principal Investigators: Hanadi Rifai (University of Houston)/ Randy Palachek (Parsons Water&Infrastructure)

TMDL for PCBs in the Houston Ship Channel
Work Order No. 582-6-70860-13

Prepared by: MPS

Date: 07-10-2007

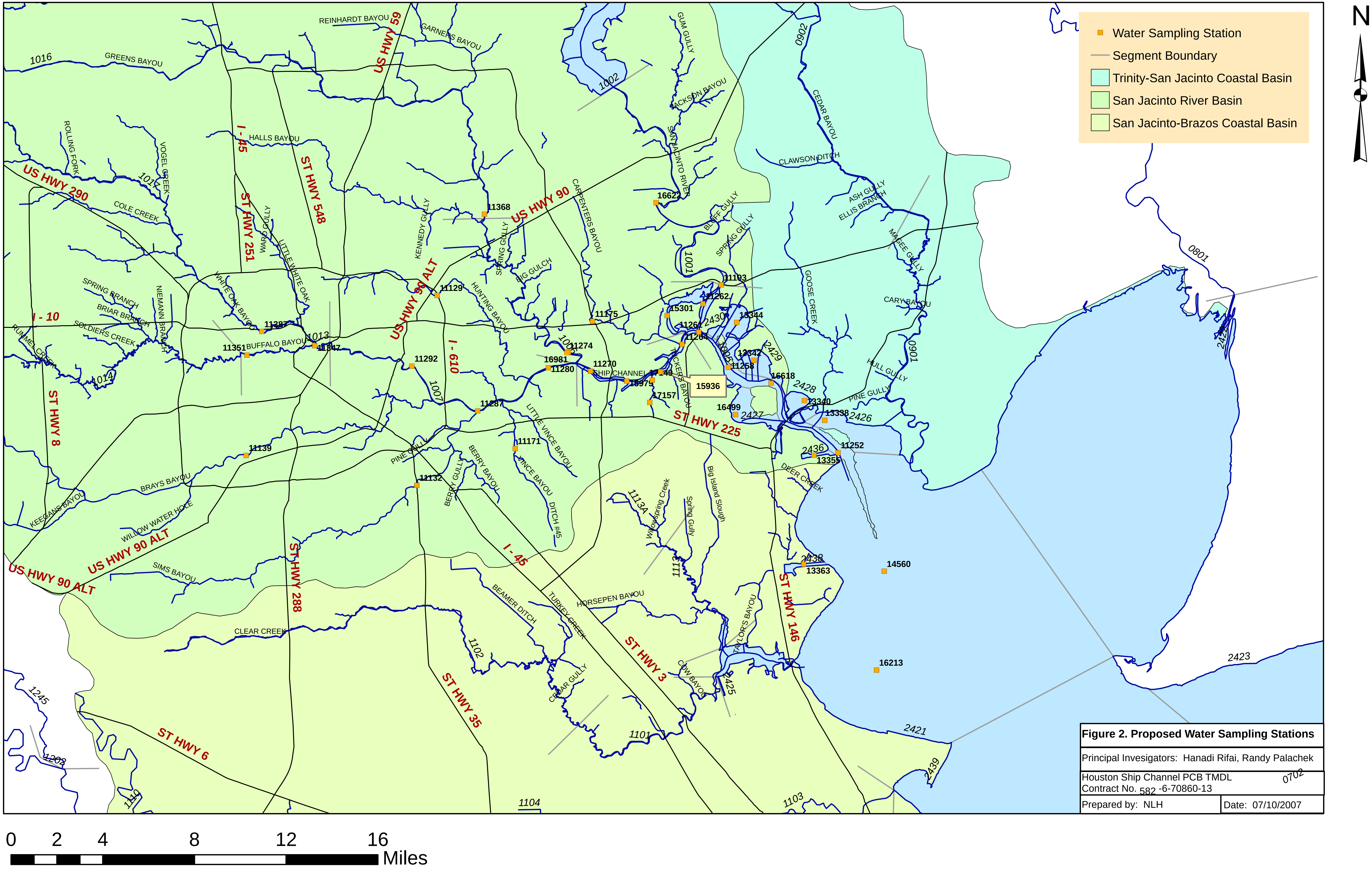


Figure 2. Proposed Water Sampling Stations

Principal Investigators: Hanadi Rifai, Randy Palachek

Houston Ship Channel PCB TMDL
Contract No. 582 -6-70860-13

Prepared by: NLH

Date: 07/10/2007

APPENDIX E - DRAFT MONITORING QAPP

Total Maximum Daily Loads for PCBs in the Houston Ship Channel System Segments 0901, 1001, 1005, 1006, 2430, 2429, 2428, 2427, 2426, 2436, 2438, and 2421

Quality Assurance Project Plan

Revision 0

Date submitted to TCEQ: 07/30/2007

Grant Title: 319 05-06 NPS
Federal Grant ID: C9-996146-11

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Total Maximum Daily Load Program
Chief Engineer's Office, Water Programs
Texas Commission on Environmental Quality
P.O. Box 13087, MC - 203
Austin, Texas 78711-3087

This QAPP is effective for a period of one year from approval date.

Questions concerning this QAPP should be directed to:
Hanadi Rifai

A1 APPROVAL PAGE

Texas Commission on Environmental Quality
Chief Engineer's Office, Water Programs

Faith Hambleton, Program Manager Date
Total Maximum Daily Load Program

Larry Koenig, Project Manager Date
Total Maximum Daily Load Program

Office of Compliance and Enforcement
Compliance Support Division

Stephen Stubbs, Manager Date
Quality Assurance Program

Kyle Girten, Quality Assurance Specialist Date
Quality Assurance Program

Monitoring Operations Division

David Manis, Manager Date
Data Management and Quality Assurance Section

University of Houston/Parsons Water & Infrastructure

Hanadi S. Rifai, Project Manager Date
University of Houston

Randy Palachek, Project Principal Date
Parsons Water & Infrastructure

Sandra de las Fuentes, Project QAO Date
Parsons

Maxxam Analytics Inc.

James Hartley, Project Manager Date

Ewa Konieczna, Laboratory QA Officer Date

Xenco Laboratories

Paula Kirtley, Project Manager Date

Aster Tekle, Laboratory QA Officer Date

Note: The Project Quality Assurance Officer will secure written documentation (such as the letter in Appendix G) from each sub-tier project participant that is not signing the QAPP (e.g., subcontractors, other units of government, laboratories) stating the organization's awareness of and commitment to requirements contained in this quality assurance project plan and any amendments or revisions of this plan. The Project Quality Assurance Officer will maintain the documentation as part of the project's quality assurance records, and will ensure that the document is available for review. **Copies will also be submitted as deliverables to the TMDL Project Manager within 30 days of QAPP approval.**

A2 TABLE OF CONTENTS

A3 DISTRIBUTION LIST

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Note: The Project Quality Assurance Officer will provide copies of this project plan and any amendments or revisions of this plan to each person on this list and to sub-tier project project participant, e.g., subcontractors, other units of government, laboratories. The Project Quality Assurance Officer will document receipt of the plan and maintain this documentation as part of the project's quality assurance records. This documentation will be available for review and will also be submitted to the TMDL Project Manager within 30 days of QAPP approval.

List of Acronyms

AWRL	Ambient Water Reporting Limit
BAF	Bioaccumulation Factor
BCF	Bioconcentration Factor
CFR	Code of Federal Regulations
CMC	Criteria Maximum Concentration
COC	Chain of Custody
CRM	Certified Reference Material
CRP	Clean Rivers Program
CWA	Clean Water Act
DMP	Data Management Plan
DQO	Data Quality Objective
DSHS	Texas Department of Safety and Health Services
EPA	Environmental Protection Agency
FRPD	Field Relative Percent Deviation
GC	Gas Chromatography
GPS	Global Positioning System
HRGC	High Resolution Gas Chromatography
HRMS	High Resolution Mass Spectrometry
IC	Ion Chromatography
LA	Load Allocation
LC	Loading Capacity
LCS	Laboratory Control Sample (formely Laboratoty Control Standard)
LCSD	Laboratory Control Sample Duplicate (formerly Laboratory Control Standard Duplicate
LIMS	Laboratory Information Management System
LOD	Limit of Detection (formerly Method Detection Limit or MDL)
LOQ	Limit of Quantification (formerly Reporting Limit or RL)
MDMA	Monitoring Data Management and Analysis
MS	Matrix Spike
NCTCOG	North Central Texas Council of Governments
NELAC	National Environmental Laboratory Accreditation Conference
NPS	Nonpoint Source
PCB	Polychlorinated Biphenyl
PS	Point Source
QA/QC	Quality Assurance/Quality Control
QAM	Quality Assurance Manual
QAO	Quality Assurance Officer
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QAS	Quality Assurance Specialist
QMP	Quality Management Plan
RL	Changed to LOQ
RPD	Relative Percent Deviation
SOP	Standard Operating Procedure
SWQM	Surface Water Quality Monitoring
SWQMIS	Surface Water Quality Monitoring Information System (formerly TRACS)

TCEQ	Texas Commission on Environmental Quality (formerly Natural Resource Conservation Commission, TNRCC)
TMDL	Total Maximum Daily Load
TOC	Total Organic Carbon
TSS	Total Suspended Solids
TSWQS	Texas Surface Water Quality Standards
UH	University of Houston
USGS	United States Geological Survey
VSS	Volatile Suspended Solids
WLA	Wasteload Allocation
WMS	Water Monitoring Solutions

A4 PROJECT/TASK ORGANIZATION

Description of Responsibilities

TCEQ Chief Engineer's Office
Water Programs

Faith Hambleton
TMDL Program Manager
Responsible for managing the TCEQ TMDL Program and supervises the TMDL staff. Oversees the development of QA guidance for the TMDL Team to ensure it is within pertinent frameworks of the TCEQ. Reviews and/or approves all TMDL Projects, QA audits, QAPPs, agency QMPs, corrective action reports, work plans, and contracts. Enforces corrective action where QA protocols are not met. Ensures TCEQ TMDL personnel are fully trained and TMDL projects are adequately staffed.

Larry Koenig
TMDL Project Manager
Responsible for ensuring that the project delivers data of known quality, quantity, and type on schedule to achieve project objectives. Provides the primary point of contact between the University of Houston/Parsons Team and the TCEQ. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified in the contract. Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TCEQ participants. Responsible for verifying that the QAPP is followed by the University of Houston/Parsons Team. Notifies the TCEQ QAS, TMDL QAS, and TMDL Program Manager of significant project nonconformances and corrective actions taken as documented in CARs and/or quarterly progress reports from the University of Houston Project Manager.

Kerry Niemann
TMDL Data Manager
Tracks and verifies data generated by TMDL projects. Responsible for receiving data (Event/Results Files) from TMDL Project Managers, reviewing checklists from TMDL Project Managers, and loading project associated data sets into SWQMIS. The SWQMIS data loader identifies invalid stations, invalid parameter codes, outliers, and orphans. Deficiencies are provided to Project Managers via a SWQMIS Data Loading Validator Report. Ensures the data deficiencies are corrected by the University of Houston before data sets are accepted and loaded by SWQMIS. Provides quality assured data sets to TCEQ Information Resources to be uploaded into the SWQMIS. Coordinates correction of data set errors with TMDL Project Manager and TCEQ Information Resources Staff.

TCEQ Compliance Support Division

Kyle Girten
TMDL Quality Assurance Specialist
Assists the TCEQ TMDL QAS, Program Manager, and Project Manager on QA-related issues. Coordinates reviews and approves QAPPs and amendments or revisions. Prepares and distributes annual audit plans. Conveys QA problems to appropriate TCEQ management. Monitors

implementation of corrective actions. Coordinates and conducts audits. Ensures maintenance of QAPPs and audit records for the TMDL program.

TCEQ Monitoring Operations Division

Data Management and Quality Assurance Data Manager

Reviews QAPP for valid surface water quality monitoring stations, checks validity of parameter codes, submitting agency codes, collecting agency codes, monitoring type codes, and tag prefixes to ensure that data will be reported following the *Surface Water Quality Monitoring Data Management Reference Guide (DMRG)*, 2007 or most current version. Analyzes SWQMIS to identify Level 1 data validation inconsistencies and reports any findings to TMDL Project Managers or TMDL Data Managers as appropriate. Serves as Monitoring Operations data management customer service representative for the TMDL Project Manager. Provides training to the TMDL Data Manager and TMDL Project Manager to ensure proper data submittal. Reviews and approves applicable QAPPs.

TCEQ Field Operations Division

Linda Broach
TCEQ Region 12 TMDL Staff

Assists in the development of the project's water quality monitoring plan as appropriate. Ensures that the water quality monitoring plan in Appendix B adequately represents the local water quality conditions that may account for the observed impairment by corresponding with respective FOD Regional Field Staff. Works with the TMDL Project Manager to resolve problems with water quality monitoring. Maintains contact with TCEQ Project Manager to ensure coordination of issues.

University of Houston/Parsons

Hanadi Rifai
University of Houston Project Manager

The University of Houston Project Manager is responsible for ensuring that tasks and other requirements in the contract are executed on time and with the quality assurance/quality control requirements in the system as defined by the contract and in the project QAPP; assessing the quality of subcontractor/participant work; submitting accurate and timely deliverables to the TCEQ TMDL Project Manager; and coordinating attendance at conference calls, training, meetings, and related project activities with the TCEQ. Responsible for verifying that the QAPP is distributed and followed by the University of Houston (including all subcontractors) and that the project is producing data of known and acceptable quality for reporting to the TCEQ. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical and field data, including the facilitation of audits and the implementation, documentation, verification and reporting of corrective actions.

Randy Palachek
Parsons Water & Infrastructure Project Principal

Responsible for ensuring that tasks performed by Parsons are executed on time and with the quality assurance/ quality control requirements in the system as defined by the contract and in the QAPP; submitting accurate and timely deliverables to the University of Houston Project Manager; and coordinating attendance at conference calls, training, meetings, and related project activities with the University of Houston. Responsible for verifying that the project is producing data of known and acceptable quality for reporting to the TCEQ. Responsible for ensuring adequate training and supervision of all activities involved in generating analytical data, corrective action taken as well as facilitating internal audits.

Sandra de las Fuentes
Project Quality Assurance Officer
Responsible for coordinating development and implementation of the University of Houston's QA program. Responsible for writing and maintaining QAPPs and monitoring its implementation. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Ensures the data collected for the project is of known and acceptable quality and adheres to the specifications of the QAPP. Responsible for maintaining written records of sub-tier commitment to requirements specified in this QAPP. Responsible for identifying, receiving, and maintaining project quality assurance records. Responsible for compiling and submitting the QA report. Responsible for coordinating with the TCEQ QAS to resolve QA-related issues. Notifies the University of Houston Project Manager and TCEQ Project Manager of particular circumstances which may adversely affect the quality of data. Coordinates the research and review of technical QA material and data related to water quality monitoring system design and analytical techniques. Conducts assessments of participating organizations during the life of the project as noted in Section C1. Coordinates and monitors deficiencies, nonconformances and corrective actions, and completes CARs. Also implements or ensures implementation of corrective actions needed to resolve nonconformances noted during assessments.

James Hartley
Maxxam Analytics Project Manager
Responsible for supervision of laboratory personnel that generate analytical data for the project. Responsible for ensuring NELAC accreditation is obtained and kept current in order to analyze TCEQ samples. Responsible for ensuring that laboratory personnel involved in generating analytical data have adequate training and a thorough knowledge of the QAPP and all SOPs specific to the analyses or task performed and/or supervised. Responsible for oversight of all laboratory operations ensuring that all QA/QC requirements are met, documentation related to the analysis is complete and adequately maintained, and that results are reported accurately. Responsible for ensuring that corrective actions are implemented, documented, reported and verified.

Ewa Konieczna
Maxxam Analytics Laboratory Quality Assurance Officer
Monitors the implementation of the QAM/QAP within the laboratory to ensure complete compliance with project data quality objectives as defined by the contract and in the QAPP. Conducts in-house audits to ensure compliance with written SOPs and to identify potential problems. Responsible for supervising and verifying all aspects of the QA/QC in the laboratory. Performs validation and verification of data before the report is sent to the primary contractor. Ensures that all QA reviews are conducted in a timely manner from real-time review at the bench during analysis to final pass-off of data to the QA Officer.

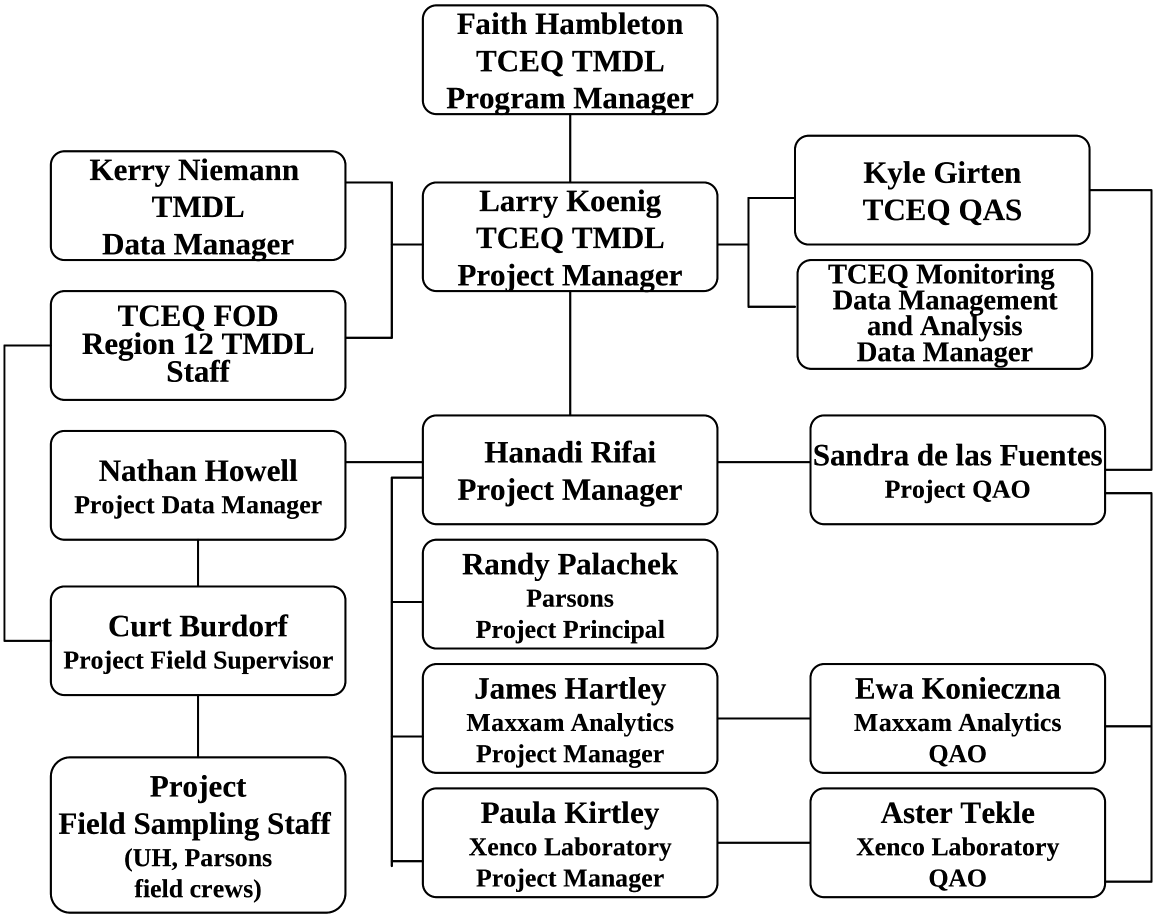
Paula Kirtley
Xenco Project Manager
Responsible for supervision of laboratory personnel that generate analytical data for the project. Responsible for ensuring NELAC accreditation is obtained and kept current in order to analyze TCEQ samples. Responsible for ensuring that laboratory personnel involved in generating analytical data have adequate training and a thorough knowledge of the QAPP and all SOPs specific to the analyses or task performed and/or supervised. Responsible for oversight of all laboratory operations ensuring that all QA/QC requirements are met, documentation related to the analysis is complete and adequately maintained, and that results are reported accurately. Responsible for ensuring that corrective actions are implemented, documented, reported and verified.

Aster Tekle
Xenco Laboratory Quality Assurance Officer
Monitors the implementation of the QAM/QAP within the laboratory to ensure complete compliance with project data quality objectives as defined by the contract and in the QAPP. Conducts in-house audits to ensure compliance with written SOPs and to identify potential problems. Responsible for supervising and verifying all aspects of the QA/QC in the laboratory. Performs validation and verification of data before the report is sent to the primary contractor. Ensures that all QA reviews are conducted in a timely manner from real-time review at the bench during analysis to final pass-off of data to the QA Officer.

Nathan Howell
Project Data Manager – University of Houston
Responsible for the acquisition, verification, and transfer of data to the TCEQ TMDL Project Manager. Oversees data management for the project. Performs data quality assurances prior to transfer of data to TCEQ in the format specified in the SWQM Data Management Reference Guide (2007) or most recent version. Ensures that the data review checklist is completed and data is submitted with appropriate codes. Provides the point of contact for the TCEQ TMDL Project Manager to resolve issues related to the data and assumes responsibility for the correction of any data errors.

Curt Burdorf
Project Field Supervisor - Parsons
Responsible for supervising all aspects of the sampling and measurement of surface waters and other parameters in the field. Responsible for the collection of water samples and field data measurements in a timely manner that meet the quality objectives specified in Section A7 (Table A7.1), as well as the requirements of Sections B1 through B8. Responsible for field scheduling, staffing, and ensuring that staff are appropriately trained. When monitoring activities include TCEQ entities the field supervisor shall coordinate with the TCEQ Project Manager. Reports status, problems, and progress to the University of Houston Project Manager.

Figure A4.1 Organization Chart



A5 PROBLEM DEFINITION/BACKGROUND

The particular problem to be addressed under this Quality Assurance Project Plan (QAPP) is described in Appendix A, the project work plan. The project is designed to ensure that data generated for the purposes described herein are scientifically valid and legally defensible.

The Texas Commission on Environmental Quality (TCEQ, formerly Texas Natural Resources Conservation Commission –TNRCC) implements the statewide approach for watershed management in Texas to improve the efficiency, effectiveness, and continuity of water quality management programs. The approach, which is summarized in *The Statewide Watershed Management Approach for Texas: The TNRCC's Framework for Implementing Water Quality Management* (TNRCC, 1997), establishes the state's process for managing water quality. It focuses on assessing watershed conditions for all waters of the state and implementing solutions where improvement is necessary. The primary goal of the approach is to ensure that management efforts provide a safe, clean, affordable water supply and healthy aquatic ecosystems for Texas.

The Total Maximum Daily Load (TMDL) Program, a major component of the approach, addresses impaired or threatened streams, lakes, and estuaries (water bodies). The primary objective of the TMDL Program is to restore and maintain the beneficial uses of impaired or threatened water bodies. The Federal Clean Water Act §303(d) list identifies "impaired" water bodies not meeting applicable water quality standards for their designated uses and requiring development of TMDLs for contaminants of concern. In general, a TMDL is the total amount of a pollutant that a water body can assimilate and still meet state water quality standards. The term also refers to the assessment necessary to establish an acceptable pollutant load for an impaired water body and to allocate the load between contributing point (PS), nonpoint (NPS), and natural background sources of pollutants in the watershed. Thus, water quality monitoring and other assessment activities are an integral part of the TMDL.

Polychlorinated biphenyls (PCBs) are extremely persistent in the environment, and can affect human health at low concentrations. As a result of PCBs found in seafood organism tissue, the Texas Department of State Health Services has issued seafood consumption advisories. Consumption advisory ADV-20 was issued in October 2001 for the Houston Ship Channel upstream of the Lynchburg Ferry crossing and all contiguous waters, including the San Jacinto River Tidal below the U.S. Highway 90 bridge -- this advisory included all species of finfish, was based on detected concentrations of PCBs and organochlorine pesticides, and partially overlapped the area covered by a consumption advisory for dioxin. Consumption advisory ADV-28 was issued January 2005 for Upper Galveston Bay and the Houston Ship Channel downstream of the Lynchburg Ferry crossing and all contiguous waters including Upper Galveston Bay north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point -- this advisory included speckled trout, also known as spotted seatrout or spotted weakfish, was based on detected concentrations of PCBs, and overlaps area also covered by the dioxin advisory. Organochlorine pesticides and dioxin have been addressed by separate prior projects.

In total, the consumption advisories for PCBs cover all or part of designated water quality segments 0901 Cedar Bayou Tidal, 1001 San Jacinto River Tidal, 1005 Houston Ship Channel/San Jacinto River Tidal, 1006 Houston Ship Channel Tidal, 1007 Houston Ship

Channel/Buffalo Bayou Tidal, 2430 Burnett Bay, 2429 Scott Bay, 2428 Black Duck Bay, 2427 San Jacinto Bay, 2426 Tabbs Bay, 2436 Barbours Cut, 2438 Bayport Channel, and 2421 Upper Galveston Bay. All parts of those segments that are covered by the PCB consumption advisories will comprise the project area. The overall purpose of this project is to develop a total maximum daily load (TMDL) allocation for PCBs in the Houston Ship Channel System, including upper Galveston Bay, and a plan for managing PCBs to correct existing water quality impairments and maintain good water quality in the future.

A6 PROJECT/TASK DESCRIPTION

Appendix A includes a detailed description of the tasks to be performed, deliverables and the schedule for this project. This QAPP covers the monitoring tasks described in the work plan. Maps of the monitoring sites and a monitoring table listing sites, parameters, and monitoring dates are provided in Appendix B.

Planned Measurements

Planned measures in the field include sampling locations recorded using a Global Positioning System (GPS) unit, standard water parameters (water depth, pH, salinity, and temperature), physical water conditions, and ambient weather conditions. Samples of fish tissue, suspended particulate material in water, dissolved organic material from water, and stormwater runoff will be collected for laboratory analysis of PCBs concentrations and related properties. These measurements are described in more detail in Appendix A.

The coordinates of all permanent sample locations not previously defined by the TCEQ Surface Water Quality Monitoring (SWQM) Program will be recorded during the first round of sampling. Subsequent rounds at the same stations will not be separately recorded to avoid creating multiple and slightly different location records for results obtained at the same station. Coordinates of existing monitoring stations will not be recorded, but a table of coordinates will be prepared from existing SWQM databases.

QAPP Revision

Until the work described is completed, this QAPP shall be revised as necessary and reissued annually on the anniversary date, or revised and reissued within 120 days of significant changes, whichever is sooner. The last approved versions of QAPPs shall remain in effect until revised versions have been fully approved; the revision must be submitted to the TCEQ for approval before the last approved version has expired. If the entire QAPP is current, valid, and accurately reflects the project goals and the organization's policy, the annual re-issuance may be done by a certification that the plan is current. This can be accomplished by submitting a cover letter stating the status of the QAPP and a copy of new, signed approval pages for the QAPP.

Amendments

Amendments to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives and methods; address deficiencies and non-conformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Requests for amendments are directed from the University of Houston Project Manager to the TCEQ

TMDL Project Manager in writing using the TMDL QAPP Amendment form. The TCEQ PM will consult with the TCEQ QAS to determine if the changes are substantive. The changes are effective immediately upon approval by the TCEQ TMDL Project Manager and Quality Assurance Specialist, or their designees, and the EPA Project Officer (if applicable). Amendments to the QAPP and the reasons for the changes will be documented, and copies of the approved QAPP Expedited Amendment form will be distributed to all individuals on the QAPP distribution list by the Project QAO.

Amendments shall be reviewed, approved, and incorporated into a revised QAPP during the annual revision process or within 120 days of the initial approval in cases of significant changes.

A7 QUALITY OBJECTIVES AND CRITERIA

The project objective is to collect water quality data that complies with TCEQ's *Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data* for surface water quality monitoring programs, and which may be used to support decisions related to TMDL development, stream standards modifications, permit decisions, and water quality assessments. The measurement performance specifications to support the project objective are specified in Table A7.1.

The QAPP is reviewed by the TCEQ to help ensure that data generated for the purposes described herein are scientifically valid and legally defensible. This review process will also help ensure that data submitted to the SWQMIS database have been collected and analyzed in a way that guarantees their reliability.

Data will be evaluated continuously by the University of Houston/Parsons Team representatives during the life-term of the project to ensure that they are of sufficient quality and quantity to meet the project goals. If the data do not meet the goals specified in Section A7, they will not be transferred to the TCEQ for upload to the SWQMIS database to ultimately be used in decision-making.

Table A7.1 - Measurement Performance Specifications

PARAMETER	**MATRIX**	**UNITS**	**METHOD**	**PARAMETER CODE**	**AWRL**	**LIMIT OF QUANTIFICATION (LOQ)**	**LOQ CHECK STANDARD % Rec**	**PRECISION (RPD of LCS/LCSD)**	**BIAS (% Rec LCS/LCSD mean)**	**LABORATORY/ ENTITY PERFORMING ANALYSIS**
pH	Water	pH units	EPA 150.1 and TCEQ SOP v1	00400	NA	NA	NA	NA	NA	Field
Conductivity	Water	µS/cm	EPA 120.1 and TCEQ SOP v1	00094	NA	NA	NA	NA	NA	Field
Temperature	Water	° C	EPA 150.1 and TCEQ SOP v1	00010	NA	NA	NA	NA	NA	Field
Days since last significant rainfall	Water	days	TCEQ SOP v1	72053	NA	NA	NA	NA	NA	Field
Flow	Water	cfs	TCEQ SOP v1	00061	NA	NA	NA	NA	NA	Field
Salinity	Water	$^o/_{oo}$ (ppt)	SM2520 and TCEQ SOP v1	00480	NA	NA	NA	NA	NA	Field
Volume sampled, XAD-2 resin	Water	liters	SOP for high-volume sampling (Attachment 1)	32000	NA	NA	NA	NA	NA	Field
Bottom depth at sampling site	Water	meters	TCEQ SOP v1	82903	NA	NA	NA	NA	NA	Field
EPA Species Code[a]	Tissue	NA	NA	74990	NA	NA	NA	NA	NA	Parsons
Texas Species Code[a]	Tissue	NA	NA	89900	NA	NA	NA	NA	NA	Parsons
Samples Species Length, Median[a]	Tissue	inches	TCEQ SOP v1	72205	NA	NA	NA	NA	NA	Parsons
Samples Species Length, Minimum[a]	Tissue	inches	TCEQ SOP v1	72203	NA	NA	NA	NA	NA	Parsons
Samples Species Length, Maximum[a]	Tissue	inches	TCEQ SOP v1	72204	NA	NA	NA	NA	NA	Parsons
Samples Species Weight, Median[a]	Tissue	grams	TCEQ SOP v1	72202	NA	NA	NA	NA	NA	Parsons
Samples Species Weight, Minimum[a]	Tissue	grams	TCEQ SOP v1	72200	NA	NA	NA	NA	NA	Parsons
Samples Species Weight, Maximum[a]	Tissue	grams	TCEQ SOP v1	72201	NA	NA	NA	NA	NA	Parsons
Anatomical Tissue Part[a]	Tissue	NA	NA	74995	NA	NA	NA	NA	NA	Parsons
Number of Species in Composite Sample[a]	Tissue	NA	NA	81615	NA	NA	NA	NA	NA	Parsons

PARAMETER	**MATRIX**	**UNITS**	**METHOD**	**PARAMETER CODE**	**AWRL**	**LIMIT OF QUANTIFICATION (LOQ)**	**LOQ CHECK STANDARD % Rec**	**PRECISION (RPD of LCS/LCSD)**	**BIAS (% Rec LCS/LCSD mean)**	**LABORATORY/ ENTITY PERFORMING ANALYSIS**
Number of Individuals in Composite Sample[a]	Tissue	NA	NA	81614	NA	NA	NA	NA	NA	Parsons
TSS	Water	mg/L	EPA 160.2	00530	4	4	NA	20	80-120	Xenco Laboratories
DOC	Water	mg/L	EPA 415.2	00681	0.5	0.5	75-125	20	80-120	Xenco Laboratories
TPH	Water	mg/L	TX 1005	04720	5	5	70-135	25	70-135	Xenco Laboratories
TOC	Sediment	mg/kg	Lloyd Khan	81951	100	100	75-125	20	80-120	Xenco Laboratories
TPH	Sediment	mg/kg	TX 1005	89995	50	50	70-135	25	70-135	Xenco Laboratories
Solids Content	Sediment	%	EPA 160.3	81373	2	2	NA	NA	NA	Xenco Laboratories
Lipid Content	Tissue	%	AOAC 996.06	xx	0.5	0.5	90-110	25	90-110	Maxxam Analytics
PCB 1	Water, dissolved	ng/L	EPA 1668A	19509	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 2	Water, dissolved	ng/L	EPA 1668A	19510	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 3	Water, dissolved	ng/L	EPA 1668A	49816	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 4	Water, dissolved	ng/L	EPA 1668A	19511	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 5	Water, dissolved	ng/L	EPA 1668A	19512	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 6	Water, dissolved	ng/L	EPA 1668A	19003	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 7	Water, dissolved	ng/L	EPA 1668A	19002	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 8	Water, dissolved	ng/L	EPA 1668A	19513	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 9	Water, dissolved	ng/L	EPA 1668A	19514	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 10	Water, dissolved	ng/L	EPA 1668A	19515	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 11	Water, dissolved	ng/L	EPA 1668A	19516	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 13/12	Water, dissolved	ng/L	EPA 1668A	20392	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 14	Water, dissolved	ng/L	EPA 1668A	19062	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 15	Water, dissolved	ng/L	EPA 1668A	19519	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 16	Water, dissolved	ng/L	EPA 1668A	19520	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 17	Water, dissolved	ng/L	EPA 1668A	19007	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 19	Water, dissolved	ng/L	EPA 1668A	19005	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 21/33	Water, dissolved	ng/L	EPA 1668A	20399	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 22	Water, dissolved	ng/L	EPA 1668A	19013	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 23	Water, dissolved	ng/L	EPA 1668A	19523	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 24	Water, dissolved	ng/L	EPA 1668A	19524	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 25	Water, dissolved	ng/L	EPA 1668A	49820	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 26/29	Water, dissolved	ng/L	EPA 1668A	20405	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	**MATRIX**	**UNITS**	**METHOD**	**PARAMETER CODE**	**AWRL**	**LIMIT OF QUANTIFICATION (LOQ)**	**LOQ CHECK STANDARD % Rec**	**PRECISION (RPD of LCS/LCSD)**	**BIAS (% Rec LCS/LCSD mean)**	**LABORATORY/ ENTITY PERFORMING ANALYSIS**
PCB 27	Water, dissolved	ng/L	EPA 1668A	19525	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 28/20	Water, dissolved	ng/L	EPA 1668A	20406	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 30/18	Water, dissolved	ng/L	EPA 1668A	20407	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 31	Water, dissolved	ng/L	EPA 1668A	19529	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 32	Water, dissolved	ng/L	EPA 1668A	19530	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 34	Water, dissolved	ng/L	EPA 1668A	19531	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 35	Water, dissolved	ng/L	EPA 1668A	19532	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 36	Water, dissolved	ng/L	EPA 1668A	19533	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 37	Water, dissolved	ng/L	EPA 1668A	19534	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 38	Water, dissolved	ng/L	EPA 1668A	19535	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 39	Water, dissolved	ng/L	EPA 1668A	19536	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 40/41/71	Water, dissolved	ng/L	EPA 1668A	20415	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 42	Water, dissolved	ng/L	EPA 1668A	19538	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 43	Water, dissolved	ng/L	EPA 1668A	19539	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 44/47/65	Water, dissolved	ng/L	EPA 1668A	20416	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 45/51	Water, dissolved	ng/L	EPA 1668A	20408	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 46	Water, dissolved	ng/L	EPA 1668A	19015	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 48	Water, dissolved	ng/L	EPA 1668A	19541	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 52	Water, dissolved	ng/L	EPA 1668A	19016	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 53/50	Water, dissolved	ng/L	EPA 1668A	20409	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 54	Water, dissolved	ng/L	EPA 1668A	19543	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 55	Water, dissolved	ng/L	EPA 1668A	19544	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 56	Water, dissolved	ng/L	EPA 1668A	19545	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 57	Water, dissolved	ng/L	EPA 1668A	19546	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 58	Water, dissolved	ng/L	EPA 1668A	19547	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 59/62/75	Water, dissolved	ng/L	EPA 1668A	20410	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 60	Water, dissolved	ng/L	EPA 1668A	19549	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 61/70/74/76	Water, dissolved	ng/L	EPA 1668A	20411	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 63	Water, dissolved	ng/L	EPA 1668A	49823	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 64	Water, dissolved	ng/L	EPA 1668A	19552	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 66	Water, dissolved	ng/L	EPA 1668A	49824	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 67	Water, dissolved	ng/L	EPA 1668A	19553	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 68	Water, dissolved	ng/L	EPA 1668A	19554	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 69/49	Water, dissolved	ng/L	EPA 1668A	20393	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 72	Water, dissolved	ng/L	EPA 1668A	19558	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 73	Water, dissolved	ng/L	EPA 1668A	19559	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 77	Water, dissolved	ng/L	EPA 1668A	19562	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 78	Water, dissolved	ng/L	EPA 1668A	19563	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 79	Water, dissolved	ng/L	EPA 1668A	19564	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 80	Water, dissolved	ng/L	EPA 1668A	19565	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 81	Water, dissolved	ng/L	EPA 1668A	19566	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 82	Water, dissolved	ng/L	EPA 1668A	19036	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 83/99	Water, dissolved	ng/L	EPA 1668A	20290	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 84	Water, dissolved	ng/L	EPA 1668A	19567	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 88/91	Water, dissolved	ng/L	EPA 1668A	20412	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 89	Water, dissolved	ng/L	EPA 1668A	49826	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 92	Water, dissolved	ng/L	EPA 1668A	19571	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 94	Water, dissolved	ng/L	EPA 1668A	19573	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 95	Water, dissolved	ng/L	EPA 1668A	49825	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 96	Water, dissolved	ng/L	EPA 1668A	19574	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 100/93/102/ 98	Water, dissolved	ng/L	EPA 1668A	20413	0.013	0.4[b]	50-150	30	50-150	Maxxam Analytics
PCB 103	Water, dissolved	ng/L	EPA 1668A	19579	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 104	Water, dissolved	ng/L	EPA 1668A	19580	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 105	Water, dissolved	ng/L	EPA 1668A	19581	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 106	Water, dissolved	ng/L	EPA 1668A	19582	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 107	Water, dissolved	ng/L	EPA 1668A	19583	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 108/124	Water, dissolved	ng/L	EPA 1668A	20291	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 109/119/86/ 97/125/87	Water, dissolved	ng/L	EPA 1668A	20292	0.013	0.6[b]	50-150	30	50-150	Maxxam Analytics
PCB 110/115	Water, dissolved	ng/L	EPA 1668A	20394	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 111	Water, dissolved	ng/L	EPA 1668A	19587	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 112	Water, dissolved	ng/L	EPA 1668A	19588	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 113/90/101	Water, dissolved	ng/L	EPA 1668A	20395	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 114	Water, dissolved	ng/L	EPA 1668A	19590	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 117/116/85	Water, dissolved	ng/L	EPA 1668A	20396	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 118	Water, dissolved	ng/L	EPA 1668A	19040	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	**MATRIX**	**UNITS**	**METHOD**	**PARAMETER CODE**	**AWRL**	**LIMIT OF QUANTIFICATION (LOQ)**	**LOQ CHECK STANDARD % Rec**	**PRECISION (RPD of LCS/LCSD)**	**BIAS (% Rec LCS/LCSD mean)**	**LABORATORY/ ENTITY PERFORMING ANALYSIS**
PCB 120	Water, dissolved	ng/L	EPA 1668A	19595	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 121	Water, dissolved	ng/L	EPA 1668A	19596	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 122	Water, dissolved	ng/L	EPA 1668A	19597	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 123	Water, dissolved	ng/L	EPA 1668A	19598	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 126	Water, dissolved	ng/L	EPA 1668A	19601	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 127	Water, dissolved	ng/L	EPA 1668A	19602	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 128/166	Water, dissolved	ng/L	EPA 1668A	20397	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 130	Water, dissolved	ng/L	EPA 1668A	19605	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 131	Water, dissolved	ng/L	EPA 1668A	19606	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 132	Water, dissolved	ng/L	EPA 1668A	19607	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 133	Water, dissolved	ng/L	EPA 1668A	19608	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 134/143	Water, dissolved	ng/L	EPA 1668A	20398	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 136	Water, dissolved	ng/L	EPA 1668A	19034	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 137	Water, dissolved	ng/L	EPA 1668A	19611	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 138/163/129	Water, dissolved	ng/L	EPA 1668A	20414	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 139/140	Water, dissolved	ng/L	EPA 1668A	20400	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 141	Water, dissolved	ng/L	EPA 1668A	19043	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 142	Water, dissolved	ng/L	EPA 1668A	19615	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 144	Water, dissolved	ng/L	EPA 1668A	19617	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 145	Water, dissolved	ng/L	EPA 1668A	19618	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 146	Water, dissolved	ng/L	EPA 1668A	19041	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 147/149	Water, dissolved	ng/L	EPA 1668A	20401	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 148	Water, dissolved	ng/L	EPA 1668A	19620	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 150	Water, dissolved	ng/L	EPA 1668A	19621	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 151/135	Water, dissolved	ng/L	EPA 1668A	20402	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 152	Water, dissolved	ng/L	EPA 1668A	19622	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 153/168	Water, dissolved	ng/L	EPA 1668A	20403	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 154	Water, dissolved	ng/L	EPA 1668A	19624	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 155	Water, dissolved	ng/L	EPA 1668A	19625	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 156/157	Water, dissolved	ng/L	EPA 1668A	20417	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 158	Water, dissolved	ng/L	EPA 1668A	49830	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 159	Water, dissolved	ng/L	EPA 1668A	19628	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 160	Water, dissolved	ng/L	EPA 1668A	19629	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 161	Water, dissolved	ng/L	EPA 1668A	19630	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 162	Water, dissolved	ng/L	EPA 1668A	19631	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 164	Water, dissolved	ng/L	EPA 1668A	19633	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 165	Water, dissolved	ng/L	EPA 1668A	19634	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 167	Water, dissolved	ng/L	EPA 1668A	19635	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 169	Water, dissolved	ng/L	EPA 1668A	19637	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 170	Water, dissolved	ng/L	EPA 1668A	19638	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 171/173	Water, dissolved	ng/L	EPA 1668A	20404	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 172	Water, dissolved	ng/L	EPA 1668A	49831	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 174	Water, dissolved	ng/L	EPA 1668A	19050	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 175	Water, dissolved	ng/L	EPA 1668A	19641	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 176	Water, dissolved	ng/L	EPA 1668A	19642	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 177	Water, dissolved	ng/L	EPA 1668A	19051	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 178	Water, dissolved	ng/L	EPA 1668A	19046	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 179	Water, dissolved	ng/L	EPA 1668A	19643	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 181	Water, dissolved	ng/L	EPA 1668A	19644	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 182	Water, dissolved	ng/L	EPA 1668A	19645	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 183	Water, dissolved	ng/L	EPA 1668A	19048	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 184	Water, dissolved	ng/L	EPA 1668A	19646	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 185	Water, dissolved	ng/L	EPA 1668A	19049	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 186	Water, dissolved	ng/L	EPA 1668A	19647	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 187	Water, dissolved	ng/L	EPA 1668A	19648	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 188	Water, dissolved	ng/L	EPA 1668A	19649	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 189	Water, dissolved	ng/L	EPA 1668A	19650	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 190	Water, dissolved	ng/L	EPA 1668A	19651	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 191	Water, dissolved	ng/L	EPA 1668A	19652	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 192	Water, dissolved	ng/L	EPA 1668A	19653	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 193/180	Water, dissolved	ng/L	EPA 1668A	20288	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 194	Water, dissolved	ng/L	EPA 1668A	19060	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 195	Water, dissolved	ng/L	EPA 1668A	19654	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 196	Water, dissolved	ng/L	EPA 1668A	19655	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 197	Water, dissolved	ng/L	EPA 1668A	19656	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 198/199	Water, dissolved	ng/L	EPA 1668A	20289	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 200	Water, dissolved	ng/L	EPA 1668A	19657	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 201	Water, dissolved	ng/L	EPA 1668A	19057	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 202	Water, dissolved	ng/L	EPA 1668A	19658	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 203	Water, dissolved	ng/L	EPA 1668A	19659	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 204	Water, dissolved	ng/L	EPA 1668A	19660	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 205	Water, dissolved	ng/L	EPA 1668A	19661	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 206	Water, dissolved	ng/L	EPA 1668A	19061	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 207	Water, dissolved	ng/L	EPA 1668A	49834	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 208	Water, dissolved	ng/L	EPA 1668A	19662	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 209	Water, dissolved	ng/L	EPA 1668A	19663	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 1	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 2	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 3	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 4	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 5	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 6	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 7	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 8	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 9	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 10	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 11	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 13/12	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 14	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 15	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 16	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 17	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 19	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 21/33	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 22	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 23	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 24	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 25	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 26/29	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	**MATRIX**	**UNITS**	**METHOD**	**PARAMETER CODE**	**AWRL**	**LIMIT OF QUANTIFICATION (LOQ)**	**LOQ CHECK STANDARD % Rec**	**PRECISION (RPD of LCS/LCSD)**	**BIAS (% Rec LCS/LCSD mean)**	**LABORATORY/ ENTITY PERFORMING ANALYSIS**
PCB 27	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 28/20	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 30/18	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 31	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 32	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 34	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 35	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 36	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 37	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 38	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 39	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 40/41/71	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 42	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 43	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 44/47/65	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 45/51	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 46	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 48	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 52	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 53/50	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 54	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 55	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 56	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 57	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 58	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 59/62/75	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 60	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 61/70/74/76	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 63	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 64	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 66	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 67	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 68	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 69/49	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 72	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 73	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 77	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 78	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 79	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 80	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 81	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 82	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 83/99	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 84	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 88/91	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 89	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 92	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 94	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 95	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 96	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 100/93/102/ 98	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.4[b]	50-150	30	50-150	Maxxam Analytics
PCB 103	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 104	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 105	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 106	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 107	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 108/124	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 109/119/86/ 97/125/87	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.6[b]	50-150	30	50-150	Maxxam Analytics
PCB 110/115	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 111	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 112	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 113/90/101	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 114	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 117/116/85	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 118	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	**MATRIX**	**UNITS**	**METHOD**	**PARAMETER CODE**	**AWRL**	**LIMIT OF QUANTIFICATION (LOQ)**	**LOQ CHECK STANDARD % Rec**	**PRECISION (RPD of LCS/LCSD)**	**BIAS (% Rec LCS/LCSD mean)**	**LABORATORY/ ENTITY PERFORMING ANALYSIS**
PCB 120	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 121	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 122	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 123	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 126	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 127	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 128/166	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 130	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 131	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 132	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 133	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 134/143	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 136	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 137	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 138/163/129	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 139/140	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 141	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 142	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 144	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 145	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 146	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 147/149	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 148	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 150	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 151/135	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 152	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 153/168	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 154	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 155	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 156/157	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 158	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 159	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 160	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	**MATRIX**	**UNITS**	**METHOD**	**PARAMETER CODE**	**AWRL**	**LIMIT OF QUANTIFICATION (LOQ)**	**LOQ CHECK STANDARD % Rec**	**PRECISION (RPD of LCS/LCSD)**	**BIAS (% Rec LCS/LCSD mean)**	**LABORATORY/ ENTITY PERFORMING ANALYSIS**
PCB 161	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 162	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 164	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 165	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 167	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 169	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 170	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 171/173	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 172	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 174	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 175	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 176	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 177	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 178	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 179	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 181	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 182	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 183	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 184	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 185	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 186	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 187	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 188	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 189	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 190	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 191	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 192	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 193/180	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 194	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 195	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 196	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 197	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 198/199	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 200	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 201	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 202	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 203	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 204	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 205	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.1[b]	50-150	30	50-150	Maxxam Analytics
PCB 206	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 207	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.3[b]	50-150	30	50-150	Maxxam Analytics
PCB 208	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 209	Water, suspended sediment	ng/L	EPA 1668A	TBD[c]	0.013	0.2[b]	50-150	30	50-150	Maxxam Analytics
PCB 1	Sediment	ng/kg	EPA 1668A	50605	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 2	Sediment	ng/kg	EPA 1668A	19871	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 3	Sediment	ng/kg	EPA 1668A	50597	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 4	Sediment	ng/kg	EPA 1668A	19872	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 5	Sediment	ng/kg	EPA 1668A	19873	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 6	Sediment	ng/kg	EPA 1668A	19874	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 7	Sediment	ng/kg	EPA 1668A	19875	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 8	Sediment	ng/kg	EPA 1668A	19876	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 9	Sediment	ng/kg	EPA 1668A	19877	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 10	Sediment	ng/kg	EPA 1668A	19878	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 11	Sediment	ng/kg	EPA 1668A	19879	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 13/12	Sediment	ng/kg	EPA 1668A	20293	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 14	Sediment	ng/kg	EPA 1668A	19882	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 15	Sediment	ng/kg	EPA 1668A	19883	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 16	Sediment	ng/kg	EPA 1668A	19884	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 17	Sediment	ng/kg	EPA 1668A	19885	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 19	Sediment	ng/kg	EPA 1668A	19887	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 21/33	Sediment	ng/kg	EPA 1668A	20294	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 22	Sediment	ng/kg	EPA 1668A	19889	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 23	Sediment	ng/kg	EPA 1668A	19890	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 24	Sediment	ng/kg	EPA 1668A	19891	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 25	Sediment	ng/kg	EPA 1668A	50595	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 26/29	Sediment	ng/kg	EPA 1668A	20295	0.02	0.02	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 27	Sediment	ng/kg	EPA 1668A	19893	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 28/20	Sediment	ng/kg	EPA 1668A	20296	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 30/18	Sediment	ng/kg	EPA 1668A	20297	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 31	Sediment	ng/kg	EPA 1668A	19896	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 32	Sediment	ng/kg	EPA 1668A	19897	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 34	Sediment	ng/kg	EPA 1668A	19899	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 35	Sediment	ng/kg	EPA 1668A	19900	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 36	Sediment	ng/kg	EPA 1668A	19901	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 37	Sediment	ng/kg	EPA 1668A	19902	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 38	Sediment	ng/kg	EPA 1668A	19903	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 39	Sediment	ng/kg	EPA 1668A	19904	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 40/41/71	Sediment	ng/kg	EPA 1668A	20298	0.03	0.03	50-150	30	50-150	Maxxam Analytics
PCB 42	Sediment	ng/kg	EPA 1668A	19907	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 43	Sediment	ng/kg	EPA 1668A	50599	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 44/47/65	Sediment	ng/kg	EPA 1668A	20299	0.03	0.03	50-150	30	50-150	Maxxam Analytics
PCB 45/51	Sediment	ng/kg	EPA 1668A	20300	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 46	Sediment	ng/kg	EPA 1668A	19910	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 48	Sediment	ng/kg	EPA 1668A	19912	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 52	Sediment	ng/kg	EPA 1668A	19915	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 50/53	Sediment	ng/kg	EPA 1668A	20301	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 54	Sediment	ng/kg	EPA 1668A	19916	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 55	Sediment	ng/kg	EPA 1668A	19917	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 56	Sediment	ng/kg	EPA 1668A	19918	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 57	Sediment	ng/kg	EPA 1668A	19919	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 58	Sediment	ng/kg	EPA 1668A	19920	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 59/62/75	Sediment	ng/kg	EPA 1668A	20302	0.03	0.03	50-150	30	50-150	Maxxam Analytics
PCB 60	Sediment	ng/kg	EPA 1668A	19922	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 61/70/74/76	Sediment	ng/kg	EPA 1668A	20303	0.04	0.04	50-150	30	50-150	Maxxam Analytics
PCB 63	Sediment	ng/kg	EPA 1668A	50602	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 64	Sediment	ng/kg	EPA 1668A	19925	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 66	Sediment	ng/kg	EPA 1668A	19927	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 67	Sediment	ng/kg	EPA 1668A	19928	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 68	Sediment	ng/kg	EPA 1668A	19929	0.01	0.01	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 69/49	Sediment	ng/kg	EPA 1668A	20304	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 72	Sediment	ng/kg	EPA 1668A	19933	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 73	Sediment	ng/kg	EPA 1668A	19934	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 77	Sediment	ng/kg	EPA 1668A	19938	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 78	Sediment	ng/kg	EPA 1668A	19939	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 79	Sediment	ng/kg	EPA 1668A	19940	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 80	Sediment	ng/kg	EPA 1668A	19941	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 81	Sediment	ng/kg	EPA 1668A	50603	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 82	Sediment	ng/kg	EPA 1668A	19942	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 83	Sediment	ng/kg	EPA 1668A	19943	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 99	Sediment	ng/kg	EPA 1668A	19957	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 84	Sediment	ng/kg	EPA 1668A	50604	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 88/91	Sediment	ng/kg	EPA 1668A	20305	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 89	Sediment	ng/kg	EPA 1668A	50606	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 92	Sediment	ng/kg	EPA 1668A	19950	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 94	Sediment	ng/kg	EPA 1668A	19952	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 95	Sediment	ng/kg	EPA 1668A	19953	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 96	Sediment	ng/kg	EPA 1668A	19954	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 100/93/102/ 98	Sediment	ng/kg	EPA 1668A	20306	0.04	0.04	50-150	30	50-150	Maxxam Analytics
PCB 103	Sediment	ng/kg	EPA 1668A	19960	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 104	Sediment	ng/kg	EPA 1668A	19961	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 105	Sediment	ng/kg	EPA 1668A	19962	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 106	Sediment	ng/kg	EPA 1668A	19963	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 107	Sediment	ng/kg	EPA 1668A	19964	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 124	Sediment	ng/kg	EPA 1668A	19980	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 108/119/86/ 97/125/87	Sediment	ng/kg	EPA 1668A	20320	0.06	0.06	50-150	30	50-150	Maxxam Analytics
PCB 110/115	Sediment	ng/kg	EPA 1668A	20307	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 111	Sediment	ng/kg	EPA 1668A	19968	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 112	Sediment	ng/kg	EPA 1668A	19969	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 113/90/101	Sediment	ng/kg	EPA 1668A	20308	0.03	0.03	50-150	30	50-150	Maxxam Analytics
PCB 114	Sediment	ng/kg	EPA 1668A	19971	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 117/116/85	Sediment	ng/kg	EPA 1668A	20309	0.03	0.03	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 118	Sediment	ng/kg	EPA 1668A	19975	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 120	Sediment	ng/kg	EPA 1668A	19976	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 121	Sediment	ng/kg	EPA 1668A	19977	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 122	Sediment	ng/kg	EPA 1668A	19978	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 123	Sediment	ng/kg	EPA 1668A	19979	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 126	Sediment	ng/kg	EPA 1668A	19982	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 127	Sediment	ng/kg	EPA 1668A	19983	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 128/166	Sediment	ng/kg	EPA 1668A	20310	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 130	Sediment	ng/kg	EPA 1668A	50614	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 131	Sediment	ng/kg	EPA 1668A	50613	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 132	Sediment	ng/kg	EPA 1668A	19986	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 133	Sediment	ng/kg	EPA 1668A	19987	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 134/143	Sediment	ng/kg	EPA 1668A	20311	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 136	Sediment	ng/kg	EPA 1668A	19990	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 137	Sediment	ng/kg	EPA 1668A	19991	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 138/163/129	Sediment	ng/kg	EPA 1668A	20312	0.03	0.03	50-150	30	50-150	Maxxam Analytics
PCB 139/140	Sediment	ng/kg	EPA 1668A	20313	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 141	Sediment	ng/kg	EPA 1668A	19995	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 142	Sediment	ng/kg	EPA 1668A	19996	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 144	Sediment	ng/kg	EPA 1668A	19998	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 145	Sediment	ng/kg	EPA 1668A	19999	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 146	Sediment	ng/kg	EPA 1668A	20000	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 147/149	Sediment	ng/kg	EPA 1668A	20314	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 148	Sediment	ng/kg	EPA 1668A	20287	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 150	Sediment	ng/kg	EPA 1668A	20003	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 151/135	Sediment	ng/kg	EPA 1668A	20315	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 152	Sediment	ng/kg	EPA 1668A	20005	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 153/168	Sediment	ng/kg	EPA 1668A	20316	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 154	Sediment	ng/kg	EPA 1668A	20007	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 155	Sediment	ng/kg	EPA 1668A	20008	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 156/157	Sediment	ng/kg	EPA 1668A	20418	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 158	Sediment	ng/kg	EPA 1668A	20011	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 159	Sediment	ng/kg	EPA 1668A	20012	0.02	0.02	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 160	Sediment	ng/kg	EPA 1668A	20013	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 161	Sediment	ng/kg	EPA 1668A	20014	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 162	Sediment	ng/kg	EPA 1668A	20015	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 164	Sediment	ng/kg	EPA 1668A	20017	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 165	Sediment	ng/kg	EPA 1668A	20018	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 167	Sediment	ng/kg	EPA 1668A	20020	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 169	Sediment	ng/kg	EPA 1668A	20022	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 170	Sediment	ng/kg	EPA 1668A	20023	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 171/173	Sediment	ng/kg	EPA 1668A	20317	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 172	Sediment	ng/kg	EPA 1668A	20025	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 174	Sediment	ng/kg	EPA 1668A	20027	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 175	Sediment	ng/kg	EPA 1668A	50612	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 176	Sediment	ng/kg	EPA 1668A	20028	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 177	Sediment	ng/kg	EPA 1668A	20029	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 178	Sediment	ng/kg	EPA 1668A	20030	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 179	Sediment	ng/kg	EPA 1668A	20031	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 181	Sediment	ng/kg	EPA 1668A	20033	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 182	Sediment	ng/kg	EPA 1668A	20034	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 183	Sediment	ng/kg	EPA 1668A	20035	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 184	Sediment	ng/kg	EPA 1668A	20036	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 185	Sediment	ng/kg	EPA 1668A	20037	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 186	Sediment	ng/kg	EPA 1668A	20038	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 187	Sediment	ng/kg	EPA 1668A	20039	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 188	Sediment	ng/kg	EPA 1668A	20040	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 189	Sediment	ng/kg	EPA 1668A	56011	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 190	Sediment	ng/kg	EPA 1668A	20041	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 191	Sediment	ng/kg	EPA 1668A	50610	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 192	Sediment	ng/kg	EPA 1668A	20042	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 193/180	Sediment	ng/kg	EPA 1668A	20318	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 194	Sediment	ng/kg	EPA 1668A	20043	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 195	Sediment	ng/kg	EPA 1668A	20044	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 196	Sediment	ng/kg	EPA 1668A	20045	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 197	Sediment	ng/kg	EPA 1668A	20046	0.01	0.01	50-150	30	50-150	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 198/199	Sediment	ng/kg	EPA 1668A	20319	0.02	0.02	50-150	30	50-150	Maxxam Analytics
PCB 200	Sediment	ng/kg	EPA 1668A	20048	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 201	Sediment	ng/kg	EPA 1668A	20049	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 202	Sediment	ng/kg	EPA 1668A	20050	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 203	Sediment	ng/kg	EPA 1668A	20051	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 204	Sediment	ng/kg	EPA 1668A	20052	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 205	Sediment	ng/kg	EPA 1668A	50607	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 206	Sediment	ng/kg	EPA 1668A	20053	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 207	Sediment	ng/kg	EPA 1668A	50592	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 208	Sediment	ng/kg	EPA 1668A	20054	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 209	Sediment	ng/kg	EPA 1668A	50593	0.01	0.01	50-150	30	50-150	Maxxam Analytics
PCB 1	Tissue	ng/g	EPA 1668A	20055	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 2	Tissue	ng/g	EPA 1668A	20056	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 3	Tissue	ng/g	EPA 1668A	20057	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 4	Tissue	ng/g	EPA 1668A	20058	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 5	Tissue	ng/g	EPA 1668A	20059	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 6	Tissue	ng/g	EPA 1668A	20060	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 7	Tissue	ng/g	EPA 1668A	20061	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 8	Tissue	ng/g	EPA 1668A	20263	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 9	Tissue	ng/g	EPA 1668A	20063	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 10	Tissue	ng/g	EPA 1668A	20064	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 11	Tissue	ng/g	EPA 1668A	20065	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 12/13	Tissue	ng/g	EPA 1668A	20351	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 14	Tissue	ng/g	EPA 1668A	20068	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 15	Tissue	ng/g	EPA 1668A	20069	0.01	0.01	20-150	25	NA	Maxxam Analytics
PCB 16	Tissue	ng/g	EPA 1668A	20070	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 17	Tissue	ng/g	EPA 1668A	20071	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 18/30	Tissue	ng/g	EPA 1668A	20355	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 19	Tissue	ng/g	EPA 1668A	20073	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 20/28	Tissue	ng/g	EPA 1668A	20354	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 21/33	Tissue	ng/g	EPA 1668A	20352	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 22	Tissue	ng/g	EPA 1668A	20076	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 23	Tissue	ng/g	EPA 1668A	20077	0.007	0.007	20-150	25	NA	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 24	Tissue	ng/g	EPA 1668A	20078	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 25	Tissue	ng/g	EPA 1668A	20079	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 26/29	Tissue	ng/g	EPA 1668A	20353	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 27	Tissue	ng/g	EPA 1668A	20081	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 31	Tissue	ng/g	EPA 1668A	20085	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 32	Tissue	ng/g	EPA 1668A	20086	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 34	Tissue	ng/g	EPA 1668A	20088	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 35	Tissue	ng/g	EPA 1668A	20089	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 36	Tissue	ng/g	EPA 1668A	20090	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 37	Tissue	ng/g	EPA 1668A	20091	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 38	Tissue	ng/g	EPA 1668A	20092	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 39	Tissue	ng/g	EPA 1668A	20093	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 40/41/71	Tissue	ng/g	EPA 1668A	20356	0.03	0.03	20-150	25	NA	Maxxam Analytics
PCB 42	Tissue	ng/g	EPA 1668A	20096	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 43	Tissue	ng/g	EPA 1668A	20097	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 44/47/65	Tissue	ng/g	EPA 1668A	20357	0.03	0.03	20-150	25	NA	Maxxam Analytics
PCB 45/51	Tissue	ng/g	EPA 1668A	20358	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 46	Tissue	ng/g	EPA 1668A	20100	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 48	Tissue	ng/g	EPA 1668A	20102	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 49/69	Tissue	ng/g	EPA 1668A	20362	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 50/53	Tissue	ng/g	EPA 1668A	20359	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 52	Tissue	ng/g	EPA 1668A	20267	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 54	Tissue	ng/g	EPA 1668A	20108	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 55	Tissue	ng/g	EPA 1668A	20109	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 56	Tissue	ng/g	EPA 1668A	20110	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 57	Tissue	ng/g	EPA 1668A	20111	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 58	Tissue	ng/g	EPA 1668A	20112	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 59/62/75	Tissue	ng/g	EPA 1668A	20360	0.03	0.03	20-150	25	NA	Maxxam Analytics
PCB 60	Tissue	ng/g	EPA 1668A	20114	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 61/70/74/76	Tissue	ng/g	EPA 1668A	20361	0.03	0.03	20-150	25	NA	Maxxam Analytics
PCB 63	Tissue	ng/g	EPA 1668A	20117	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 64	Tissue	ng/g	EPA 1668A	20118	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 66	Tissue	ng/g	EPA 1668A	20268	0.02	0.02	20-150	25	NA	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 67	Tissue	ng/g	EPA 1668A	20121	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 68	Tissue	ng/g	EPA 1668A	20122	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 72	Tissue	ng/g	EPA 1668A	20126	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 73	Tissue	ng/g	EPA 1668A	20127	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 77	Tissue	ng/g	EPA 1668A	20269	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 78	Tissue	ng/g	EPA 1668A	20132	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 79	Tissue	ng/g	EPA 1668A	20133	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 80	Tissue	ng/g	EPA 1668A	20134	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 81	Tissue	ng/g	EPA 1668A	20135	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 82	Tissue	ng/g	EPA 1668A	20136	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 83/99	Tissue	ng/g	EPA 1668A	20378	0.2	0.2	20-150	25	NA	Maxxam Analytics
PCB 84	Tissue	ng/g	EPA 1668A	20138	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 85/116/117	Tissue	ng/g	EPA 1668A	20367	0.2	0.2	20-150	25	NA	Maxxam Analytics
PCB 86/87/97/109/119/125	Tissue	ng/g	EPA 1668A	20380	0.2	0.2	20-150	25	NA	Maxxam Analytics
PCB 88/91	Tissue	ng/g	EPA 1668A	20363	0.2	0.2	20-150	25	NA	Maxxam Analytics
PCB 89	Tissue	ng/g	EPA 1668A	20143	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 90/101/113	Tissue	ng/g	EPA 1668A	20366	0.2	0.2	20-150	25	NA	Maxxam Analytics
PCB 92	Tissue	ng/g	EPA 1668A	20146	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 93/98/100/102	Tissue	ng/g	EPA 1668A	20364	0.2	0.2	20-150	25	NA	Maxxam Analytics
PCB 94	Tissue	ng/g	EPA 1668A	20148	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 95	Tissue	ng/g	EPA 1668A	20149	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 96	Tissue	ng/g	EPA 1668A	20150	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 103	Tissue	ng/g	EPA 1668A	20156	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 104	Tissue	ng/g	EPA 1668A	20157	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 105	Tissue	ng/g	EPA 1668A	20271	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 106	Tissue	ng/g	EPA 1668A	20159	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 107	Tissue	ng/g	EPA 1668A	20160	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 108/124	Tissue	ng/g	EPA 1668A	20379	0.2	0.2	20-150	25	NA	Maxxam Analytics
PCB 110/115	Tissue	ng/g	EPA 1668A	20365	0.2	0.2	20-150	25	NA	Maxxam Analytics
PCB 111	Tissue	ng/g	EPA 1668A	20164	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 112	Tissue	ng/g	EPA 1668A	20165	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 114	Tissue	ng/g	EPA 1668A	20167	0.02	0.02	20-150	25	NA	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 118	Tissue	ng/g	EPA 1668A	20272	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 120	Tissue	ng/g	EPA 1668A	20173	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 121	Tissue	ng/g	EPA 1668A	20174	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 122	Tissue	ng/g	EPA 1668A	20175	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 123	Tissue	ng/g	EPA 1668A	20176	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 126	Tissue	ng/g	EPA 1668A	20273	0.007	0.007	20-150	25	NA	Maxxam Analytics
PCB 127	Tissue	ng/g	EPA 1668A	20180	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 128/166	Tissue	ng/g	EPA 1668A	20368	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 129/138/163	Tissue	ng/g	EPA 1668A	20370	0.03	0.03	20-150	25	NA	Maxxam Analytics
PCB 130	Tissue	ng/g	EPA 1668A	20183	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 131	Tissue	ng/g	EPA 1668A	20184	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 132	Tissue	ng/g	EPA 1668A	20185	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 133	Tissue	ng/g	EPA 1668A	20186	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 134/143	Tissue	ng/g	EPA 1668A	20369	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 135/151	Tissue	ng/g	EPA 1668A	20373	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 136	Tissue	ng/g	EPA 1668A	20189	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 137	Tissue	ng/g	EPA 1668A	20190	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 139/140	Tissue	ng/g	EPA 1668A	20371	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 141	Tissue	ng/g	EPA 1668A	20194	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 142	Tissue	ng/g	EPA 1668A	20195	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 144	Tissue	ng/g	EPA 1668A	20197	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 145	Tissue	ng/g	EPA 1668A	20198	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 146	Tissue	ng/g	EPA 1668A	20199	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 147/149	Tissue	ng/g	EPA 1668A	20372	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 148	Tissue	ng/g	EPA 1668A	20201	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 150	Tissue	ng/g	EPA 1668A	20203	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 152	Tissue	ng/g	EPA 1668A	20205	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 153/168	Tissue	ng/g	EPA 1668A	20374	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 154	Tissue	ng/g	EPA 1668A	20207	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 155	Tissue	ng/g	EPA 1668A	20208	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 156/157	Tissue	ng/g	EPA 1668A	20423	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 158	Tissue	ng/g	EPA 1668A	20211	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 159	Tissue	ng/g	EPA 1668A	20212	0.02	0.02	20-150	25	NA	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 160	Tissue	ng/g	EPA 1668A	20213	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 161	Tissue	ng/g	EPA 1668A	20214	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 162	Tissue	ng/g	EPA 1668A	20215	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 164	Tissue	ng/g	EPA 1668A	20217	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 165	Tissue	ng/g	EPA 1668A	20218	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 167	Tissue	ng/g	EPA 1668A	20220	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 169	Tissue	ng/g	EPA 1668A	20222	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 170	Tissue	ng/g	EPA 1668A	20277	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 171/173	Tissue	ng/g	EPA 1668A	20375	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 172	Tissue	ng/g	EPA 1668A	20225	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 174	Tissue	ng/g	EPA 1668A	20227	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 175	Tissue	ng/g	EPA 1668A	20228	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 176	Tissue	ng/g	EPA 1668A	20229	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 177	Tissue	ng/g	EPA 1668A	20230	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 178	Tissue	ng/g	EPA 1668A	20231	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 179	Tissue	ng/g	EPA 1668A	20232	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 180/193	Tissue	ng/g	EPA 1668A	20376	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 181	Tissue	ng/g	EPA 1668A	20234	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 182	Tissue	ng/g	EPA 1668A	20235	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 183	Tissue	ng/g	EPA 1668A	20236	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 184	Tissue	ng/g	EPA 1668A	20237	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 185	Tissue	ng/g	EPA 1668A	20238	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 186	Tissue	ng/g	EPA 1668A	20239	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 187	Tissue	ng/g	EPA 1668A	20279	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 188	Tissue	ng/g	EPA 1668A	20241	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 189	Tissue	ng/g	EPA 1668A	20242	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 190	Tissue	ng/g	EPA 1668A	20243	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 191	Tissue	ng/g	EPA 1668A	20244	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 192	Tissue	ng/g	EPA 1668A	20245	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 194	Tissue	ng/g	EPA 1668A	20247	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 195	Tissue	ng/g	EPA 1668A	20280	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 196	Tissue	ng/g	EPA 1668A	20249	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 197	Tissue	ng/g	EPA 1668A	20250	0.02	0.02	20-150	25	NA	Maxxam Analytics

PARAMETER	MATRIX	UNITS	METHOD	PARAMETER CODE	AWRL	LIMIT OF QUANTIFICATION (LOQ)	LOQ CHECK STANDARD % Rec	PRECISION (RPD of LCS/LCSD)	BIAS (% Rec LCS/LCSD mean)	LABORATORY/ ENTITY PERFORMING ANALYSIS
PCB 198/199	Tissue	ng/g	EPA 1668A	20377	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 200	Tissue	ng/g	EPA 1668A	20253	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 201	Tissue	ng/g	EPA 1668A	20254	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 202	Tissue	ng/g	EPA 1668A	20255	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 203	Tissue	ng/g	EPA 1668A	20256	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 204	Tissue	ng/g	EPA 1668A	20257	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 205	Tissue	ng/g	EPA 1668A	20258	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 206	Tissue	ng/g	EPA 1668A	20281	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 207	Tissue	ng/g	EPA 1668A	20260	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 208	Tissue	ng/g	EPA 1668A	20261	0.02	0.02	20-150	25	NA	Maxxam Analytics
PCB 209	Tissue	ng/g	EPA 1668A	20282	0.02	0.02	20-150	25	NA	Maxxam Analytics

NA = not applicable

[a] Values will be recorded using the "Tissue Specimen Information Form" included in Appendix C

[b] Laboratory reporting limits for PCB congeners in water will vary with the volume of water pre-concentrated. The criteria listed here are for an unconcentrated 1-liter water sample

[c] TBD= to be determined. Codes currently exist for all the congeners in suspended sediments but in units of ng/kg. It is more appropriate to report the concentrations in units of ng/L, since there will not be a measure of the total amount of solids. Thus, new Parameter Codes will be requested from the TCEQ.

References for Table A7.1:

American Society for Testing and Materials (ASTM) Annual Book of Standards, Vol 11.02

Association of Official Analytic Chemists (AOAC) International, 1999, *Offocial Methods of Analysis*, 16th Edition, 5th Revision.

TCEQ SOP v1 - *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue,* December 2003 (RG-415) or subsequent editions.

United States Environmental Protection Agency (USEPA), "Methods for Chemical Analysis of Water and Wastes," Manual #EPA-600-4-79-020

United States Environmental Protection Agency (USEPA), "Method 1668: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS. Revision A." December 1999.

United States Environmental Protection Agency (USEPA), "Determination of Total Organic Carbon in Sediment (Lloyd Kahn Method)." Environmental Services Division, Monitoring Management Branch, Edison, NJ, July 1988.

Ambient Water Reporting Limits and Laboratory Reporting Limits

Ambient water reporting limits, or AWRLs, are the specifications at or below which data for a parameter must be reported to be compared with the freshwater screening criteria. The AWRLs specified in Table A7.1 are the program-defined reporting specifications for each analyte and yield data acceptable to meet the project objectives. The limit of quantitation (LOQ) [formerly know as the reporting limit (RL)] is the minimum level concentration, or quantity of a target variable (e.g., target analyte) that can be reported with a specified degree of confidence. The AWRL and RL for target analytes and performance limits for RLs are set forth in Table A7.1.

Note: While the AWRL is the highest acceptable level that can be reported for a given parameter, the Lead Organization should consider all possible uses of the data and may specify the limit of quantitation (LOQ) accordingly.

The laboratory is required to meet the following:

- The laboratory's LOQ for each analyte must be at or below the AWRL as a matter of routine practice.
- The laboratory will demonstrate and document on an ongoing basis the laboratory's ability to quantitate at its LOQ for each analyte by running an LOQ check standard each time that TMDL samples are analyzed.

Acceptance criteria are defined in Section B5.

Precision

Precision is the degree to which a set of observations or measurements of the same property, obtained under similar conditions, conform to themselves. It is a measure of agreement among replicate measurements of the same property, under prescribed similar conditions, and is an indication of random error.

Laboratory precision is assessed by comparing replicate analyses of laboratory control samples in the sample matrix (e.g. deionized water, sediment, commercially available tissue) or sample/duplicate pairs in the case of bacteria analysis. Precision results are compared against measured performance specifications and used during evaluation of analytical performance. Program-defined measurement performance specifications for precision are defined in Table A7.1

Field splits are used to assess the variability of sample handling, preservation, and storage, as well as the analytical process, and are prepared by splitting samples in the field. Control limits for field splits are defined in Section B5.

Bias

Bias is a statistical measurement of correctness and includes components of systemic error. A measurement is considered unbiased when the value reported does not differ from the true value.

Lab bias is verified through the analysis of laboratory control samples and LOQ Check Standards prepared with known and verified concentrations of all target analytes in the sample matrix (e.g. deionized water and commercially available tissue) and by calculating percent recovery. Results are compared against measured performance specifications and used during evaluation of analytical performance. Program-defined measurement specification for are specified in Table A7.1. Performance limits for blank analyses are discussed in Section B5.

Representativeness

Most data collected under the TMDL Program will be considered representative of ambient water quality conditions. This data will be coded with the applicable Monitoring Type Program Code found in Appendix B, Table 2.

Representativeness is a measure of how accurately a monitoring program reflects the actual water quality conditions. The representativeness of the data is dependent on 1) the sampling locations, 2) the number of samples collected, 3) the number of years and seasons when sampling is performed, 4) the number of depths sampled, and 5) the sampling procedures. Site selection and sampling of all pertinent media and use of only approved analytical methods will assure that the measurement data represents the conditions at the site.

The goal for meeting total representation of the water body is tempered by the availability of time and funding. Representativeness will be measured with the completion of samples collected in accordance with the approved QAPP and sampling plan.

Comparability

Confidence in the comparability of data sets from this project and those for similar uses is based on the commitment of project staff to use only approved sampling and analysis methods and QA/QC protocols in accordance with quality system requirements and as described in this QAPP. Comparability is also guaranteed by reporting data in standard units, by using accepted rules for significant figures, and by reporting data in a standard format as specified in the *Data Management Plan* (Appendix E), SWQM DMRG, and other data reporting forms included in this QAPP.

Completeness

The completeness of the data is basically a relationship of how much of the data is available for use compared to the total potential data. Ideally, 100% of the data should be available. However, the possibility of unavailable data due to accidents, insufficient sample volume, broken or lost samples, etc. is to be expected. Therefore, it will be a general goal of the project(s) that 90% data completion is achieved.

A8 SPECIAL TRAINING/CERTIFICATION

Field personnel will receive training in proper sampling and field analysis. Before actual sampling or field analysis occurs, they will demonstrate to the Project QA Officer their ability to properly calibrate field equipment and perform field sampling and analysis procedures. Training will be documented and retained in the University of Houston/Parsons personnel files and be available during a monitoring systems audit.

Contractors and subcontractors must ensure that laboratories analyzing samples under this QAPP meet the requirements contained in section 5.4.4 of the NELAC standards (concerning Review of Requests, Tenders, and Contracts). Laboratory analysts have a combination of experience, education, and training to demonstrate knowledge of their function.

Global Positioning System (GPS) training and certification are required in accordance with TCEQ Operating Policies 8.12: Global Positioning System. Certification can be obtained by: 1) completing an agency training class, 2) completing a suitable training class offered by an outside vendor, or 3) by providing documentation of sufficient GPS expertise and experience.

A9 DOCUMENTS AND RECORDS

The document and records that describe, specify, report, or certify activities, requirements, procedures, or results for this project and the items and materials that furnish objective evidence of the quality of items or activities are listed.

Table A9.1 Project Documents and Records

Document/Record	Location	Retention	Form
QAPP, amendments, and appendices	Univ. of Houston	5 years	Paper
QAPP distribution documentation	Univ. of Houston	5 years	Paper
Field notebooks or field data sheets	Univ. of Houston	5 years	Paper
Field equipment calibration/maintenance logs	Univ. of Houston	5 years	Paper
Chain of custody records	Univ. of Houston	5 years	Paper
Field SOPs	Univ. of Houston	5 years	Paper
Field corrective action documentation	Univ. of Houston	5 years	Paper
Laboratory sample reception logs	Lab	5 years	Paper
Laboratory corrective action documentation	Lab	5 years	Paper
Laboratory QA manuals	Lab	5 years	Paper
Laboratory SOPs	Univ. of Houston	5 years	Paper
Laboratory internal/external standards	Lab	5 years	Paper
Instrument raw data files	Lab	5 years	Electronic*
Field and Lab Instrument readings/printouts	Lab	5 years	Paper
Laboratory data reports	Univ. of Houston	5 years	Paper
Laboratory data verification for integrity, precision, bias and validation	Lab	5 years	Paper
Laboratory equipment maintenance logs	Lab	5 years	Paper
Laboratory calibration records	Lab	5 years	Electronic*
University of Houston data verification/validation	Univ. of Houston	5 years	Paper/Electronic*

TMDL data files	U of H/TCEQ	3 years	Paper/Electronic*
Progress report/final report/data	U of H/TCEQ	3 years	Paper/Electronic*

*Electronic files for loading to SWQMIS should be ASCII (DOS) pipe delimited text files. Electronic files of other types will be in appropriate formats.

Laboratory Records must be retained in accordance with the NELAC standards (NELAC standards Section 5.4.12).

The TCEQ may elect to take possession of records at the conclusion of the specified retention period.

Laboratory Data Reports

Test/data reports from the laboratory must document the test results clearly and accurately. Routine data reports should be consistent with the NELAC standards (Section 5.5.10) and include the information necessary for the interpretation and validation of data. The requirements for reporting data and the procedures are provided.

- Project/report title
- Name and address of the laboratory
- Name and address of the client
- a clear identification of the sample(s) analyzed
- identification of samples that did not meet QA requirements and why (i.e., holding times exceeded)
- clearly identified subcontract laboratory results (as applicable)
- date of sample receipt
- narrative information on QC failures or deviations from requirements that may affect the quality of results
- sample results
- units of measurement
- sample matrix
- dry weight or wet weight (as applicable)
- station information
- date and time of collection
- sample depth
- LOQ and LOD (formerly referred to as the reporting limit and the method detection limit, respectively), and quantification of results outside the working range (if applicable)
- Certification of NELAC compliance on a result by result basis

Electronic Data

The University of Houston will use the electronic data reporting formats included in the most recent version of the SWQM Data Management Reference Guide (2007). A completed data review checklist (see Appendix F) will accompany each set of electronic data.

References

TCEQ, 2007, or most recent version: *Surface Water Quality Monitoring Data Management Reference Guide.*
http://www.tnrcc.state.tx.us/water/quality/data/wqm/wdma/dmrg/2003dmrg.html

TCEQ, 2003b, or most recent version: *Surface Water Quality Monitoring Procedures Manual*.

TCEQ, 2003c. *Program Guidance & Reference Guide FY 2004-2005, Texas Clean Rivers Program*.

TNRCC, 1997. *The Statewide Watershed Management Approach for Texas: The TNRCC's Framework for Implementing Water Quality Management*. Publication No. GI-229. Texas Natural Resource Conservation Commission, Austin, TX.

TNRCC, 2000. 30 TAC §307 Water Quality Standards.

U.S. Environmental Protection Agency, 1999. *Method 1668: Chlorinated Biphenyl Congeners in Water, Soil, Sediment, and Tissue by HRGC/HRMS*. Revision A. U.S. Environmental Protection Agency, Office of Water, Engineering and Analysis Division (4303), Washington, D.C. 20460.

USEPA, 2001. *EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5,* EPA/240/B-01/003, Office of Environmental Information, Washington, DC 20460.

Warning: When references are made to documents that are not attached to the QAPP, the University of Houston Project Manager/QAO should assume responsibility for compliance of the documentation with the procedures and requirements set forth in the QAPP.

B1 SAMPLING PROCESS DESIGN

See Appendix B for sampling process design and monitoring schedule associated with data collected under this QAPP.

B2 SAMPLING METHODS

Field Sampling Procedures

The University of Houston/Parsons Team will follow the field sampling procedures documented in the TCEQ *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue, 2003* (RG-415) and *Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data, 2005* (RG-416). Additional procedures for field sampling outlined in this section reflect specific requirements for sampling under this TMDL Project and/or provide additional clarification. These additional procedures must be consistent with TCEQ field sampling procedures.

Sample Volume, Container Types, Minimum Sample Volume, Preservation Requirements, and Holding Time Requirements.

Table B2.1 Field Sampling and Handling Procedures

Parameter	Matrix	Container	Preservation	Sample Volume	Holding Time
TSS	Water	Pre-cleaned polyethylene or glass bottles	4^oC, dark	500 mL	7 days
TPH	Water	40 mL vials With teflon liners	HCl to pH<2, zero head space, 4^oC, dark	40 mL	14 days
TOC	Sediment	Pre-cleaned amber glass jars with Teflon seal	4^oC, dark	40 g	28 days
TPH	Sediment	Glass jars with teflon liners	4^oC, dark	4 oz	14 days
PCBs	Water[a] (Dissolved)	XAD-2 resin cartridge	0-4^o C, dark	100-400 L	1 year
PCBs	Water[a] (Suspended sediment)	glass fiber cartridge filter	0-4^o C, dark	100-400 L	1 year

Parameter	**Matrix**	**Container**	**Preservation**	**Sample Volume**	**Holding Time**
PCBs	Sediment	Pre-combusted borosilicate glass jars with Teflon-lined screw cap	<4^{o}C, dark	100 g	1 year
PCBs	Fish tissue	Aluminum foil	Freeze	50-100 g	1 year
Lipid content	Fish tissue	Aluminum foil	Freeze	3 g	1 year

[a] Refers to ambient water, effluent, and runoff samples.

Sample Containers

Filters from high-volume sampling of particulate matter in water will be individually wrapped in aluminum foil and placed into new Ziploc® bags, then grouped by sampling station in a second new Ziploc® bag. Stainless steel XAD-2 resin columns from high-volume sampling of dissolved PCBs will be capped and wrapped in aluminum foil, then placed into new Ziploc® bags. Sediment samples will be collected in pre-cleaned glass jars.

Processes to Prevent Cross Contamination

Pre-cleaned glass jars will be combusted in a muffle furnace at 450^{0}C for 4 hours to remove any remaining organic matter and contaminants. Glass fiber filters utilized in water sampling for PCBs will be wrapped in aluminum foil in groups of 2, then combusted in a muffle furnace at 450^0 C for 4 hours to remove any remaining organic matter and contaminants.

Because they are re-used, and cannot be combusted to remove organic materials, XAD-2 resin columns have a greater potential for cross-contamination. They are Soxhlet-extracted and the column bodies, column ends and plugs plus any mesh inserts are soap and water washed and solvent rinsed. During cleaning they are handled with solvent rinsed gloves or forceps and they are finally wrapped in cleaned aluminum foil. XAD-2 resin will not be re-used. Columns will be re-packed with new, trace-cleaned resin. A portion of resin from each batch will be analyzed for contamination prior to sending that batch to the field.

Specific procedures to prevent cross-contamination of laboratory glassware and apparatus, sample containers, XAD-2 resin, and glass fiber filters are described in the laboratories' SOPs. These SOPs are available upon request.

Procedures outlined in the *TCEQ Surface Water Quality Procedures Manual* outline the necessary steps to prevent cross-contamination of conventional water and tissue samples. These include items such as direct collection into sample containers, when possible; and certified containers for organics. Field QC samples as discussed in Section B5 are collected to verify that cross-contamination has not occurred.

Documentation of Field Sampling Activities

Field sampling activities are documented on field data sheets as presented in Appendix C. Flow work sheets and multi-probe calibration records are part of the field data record. For all visits, station ID, location, sampling time, sampling date, sampling depth, preservatives added to samples and sample collector's name/signature are recorded. Values for all measured field parameters are also recorded. Detailed observational data are recorded including water appearance, weather, biological activity, stream uses, watershed or instream activities, unusual odors, specific sample information, missing parameters (items that were to have been sampled that day, but weren't), days since last significant rainfall, and flow severity.

Recording Data

For the purposes of this section and subsequent sections, all field and laboratory personnel follow the basic rules for recording information as documented below:

1. Legible writing in indelible, waterproof ink with no modifications, write-overs or cross-outs;
2. Changes should be made by crossing out original entries with a single line, entering the changes, and initialing and dating the corrections;
3. Close-outs on incomplete pages with an initialed and dated diagonal line.

Deviations from Sampling Method Requirements or Sample Design, and Corrective Action

Examples of deviations from sampling method requirements or sample design include but are not limited to such things as inadequate sample volume due to spillage or container leaks, failure to preserve samples appropriately, contamination of a sample bottle during collection, storage temperature and holding time exceedance, sampling at the wrong site, etc. Any deviations from the QAPP and appropriate sampling procedures may invalidate resulting data and may require corrective action. Corrective action may include for samples to be discarded and re-collected. It is the responsibility of the University of Houston Project Manager, in consultation with the Project QAO, to ensure that the actions and resolutions to the problems are documented and that records are maintained in accordance with this QAPP. In addition, these actions and resolutions will be conveyed to the TMDL Project Manager both verbally and in writing in the project progress reports and by completion of a corrective action report (CAR).

Corrective Action Reports (CARs) document: root cause(s); programmatic impact(s); specific corrective action(s) to address any deviations; action(s) to prevent recurrence; individual(s) responsible for each action; the timetable for completion of each action; and the means by which completion of each corrective action will be documented. CARs will be included with project progress reports. In addition, significant conditions (i.e., situations which, if uncorrected, could have a serious effect on safety or on the validity or integrity of data) will be reported to the TCEQ immediately both verbally and in writing.

B3 SAMPLE HANDLING AND CUSTODY

Sample Tracking

Proper sample handling and custody procedures ensure the custody and integrity of samples beginning at the time of sampling and continuing through transport, sample receipt, preparation, and analysis.

A sample is in custody if it is in actual physical possession or in a secured area that is restricted to authorized personnel. The Chain of Custody (COC) form is a record that documents the possession of the samples from the time of collection to receipt in the laboratory. The list of items below are included on the COC form (See Appendix D for sample form).

1. Date and time of sample collection, shipping and receiving
2. Site identification
3. Sample matrix
4. Number of containers
5. Preservative used or if the sample was filtered
6. Analyses required
7. Name of collector
8. Custody transfer signatures and dates and time of transfer
9. Name of laboratory admitting the sample
10. Bill of lading *(if applicable)*

Sample Labeling

Samples will be labeled on the container with an indelible, waterproof marker. Label information will include: site identification, date and time of sample collection, sample type (water, sediment, etc), preservative added (if applicable), number of samples included and name of collectors.

Sample Handling

Water sample collection

Water column samples will be taken using the high-volume sampling technique. The sampling unit will be operated continuously until the desired volume of water has been filtered. The depth of the inlet will be switched every 30 minutes to obtain a vertical composite that will be more representative of an average water column concentration. See Attachment 1 for the SOPs for high-volume sampling of in-stream water. Once sampling is complete at a location, samples will be handled as follows:

*Glass Fiber Filters***.** Two pieces of heavy-duty aluminum foil large enough to envelop the filters will be placed on a clean, flat surface. Next, the housing unit will be removed without jostling the filter inside**.** While holding the filter housing over the foil, the used filter will be removed from the housing using clean tongs and wrapped in both pieces of foil. After this, the wrapped filter will be labeled with date and sample ID and, then, placed in a Ziploc® bag. The plastic bag will be packed in ice chests for shipment to the UH field office.

XAD-2 Resin Columns. First, the column will be unscrewed from the post-filter line, and the end cap replaced. Then, the column will be unscrewed from the post-column line, and the end cap replaced. After that, the column will be wrapped in aluminum foil and placed in a Ziploc® bag, and the bag will be labeled with date and sample ID. The bag will be placed in ice chests for shipment to the UH field office.

At the UH field office, samples will be kept refrigerated at 4°C or less. Once a week, the samples will be packed on wet ice in coolers and shipped to the PCB laboratory via overnight mail.

Runoff sample collection

Runoff samples will be taken using the high-volume sampling technique following the methodology and procedure described in Attachment 1 of this QAPP.

Effluent sample collection

Effluent samples will be collected from the final discharge (after dechlorination) using the high-volume sampling technique following the methodology and procedure described in Attachment 1 of this QAPP.

Sediment sample collection

Bed sediment samples will be collected with a stainless steel Ponar, Eckman, or Peterson dredge. Prior to collection at each sample site, the dredge, stainless steel spoon, and polyethylene or stainless steel tray will be rinsed with de-ionized water, then ambient water. Samples will be collected and deposited into a stainless steel bucket. A minimum of three grab samples will be composited using only the top 5 centimeters of sediment, mixed thoroughly with a clean stainless steel spoon, and deposited into a labeled, pre-cleaned amber glass jar with a Teflon seal. Separate samples of the same mixture will be prepared for TOC, solids content, and TPH. Grab samples will not be collected from the same area; the dredge will be used at various locations across the stream. After sample collection, all sediment samples will be placed into coolers and packed on ice in the field for shipment to the UH field office where they will be kept refrigerated at 4°C or less. Once a week, the samples will be packed on wet ice in coolers and shipped to the laboratories via overnight mail.

Fish tissue sample collection

All fish tissue sample collections will be conducted using procedures that are consistent with those documented in the TCEQ SWQM Procedures Manual as indicated in Table A.7.1.

Up to two species will be sampled at each location based on the following order:

- Croakers/Trout – Sciaenidae family: speckled (spotted) seatrout (*Cynoscion nebulosus*), sand seatrout (*Cynoscion arenarious*), and Atlantic croaker (*Micropogonias undulates*)
- Catfish - hardhead catfish (*Arius felis*), blue catfish (*Ictalurus furcatus*), and channel catfish (*Ictalurus punctatus*).

If necessary, the sample collection crew will make field substitutions of fish species using best professional judgment. An experimental gill net will be baited with shrimp to catch enough fish to obtain 50-100 grams of muscle tissue. A minimum of three fish of the same species (optimum of 5) will be collected from each sample station to give a representative sample. Fish with a total length of 300 mm or larger will be the target length for collection. Attempts will be made to keep only fish within approximately 10 to 20% of the same length and weight for any sample at a station.

When fish collection at a station is completed for a given day, fish of the apropriate species and approximate size/weight will be placed into a large industrial strength Ziplock®-type plastic bag (for that station) . The bag will be labeled with the station number, date collected, time collected, species collected, number of fish, and placed into a cooler on ice. Once the appropriate number of individual fish (of the same species and similar size/weight) have been collected for a station, the fish will be measured and weighed.

Collected fish will then be filleted for muscle tissue with a clean stainless steel knife (scrubbed with alconox soap and water, rinsed with distilled water), packed in clean foil with the dull side facing the tissue and placed into a Ziploc® bag for each sample station. Fillets will be taken from the left side of the fish. A 3 gram subsample will be prepared for lipid content analysis. The right side fillet may be used as a duplicate sample. UH/Parsons will retain a sample sized aliquot of the right side fillets of all fish (except the duplicate sample), frozen at the University of Houston until results are reviewed. Care will be taken to not puncture any internal organs or blood vessels. Sample tissue is not to be rinsed after preparation.

All collected fish samples will be frozen (if stored for shipping at a later date) or packed on ice for shipment to the laboratory. The laboratory will composite all fillets in a sample container into a single sample for analysis.

Total Suspended Solids (TSS, DOC, TPH)

Water samples will also be collected for TSS and DOC analyses. Pre-cleaned glass bottles will be used to collect samples for TSS and pre-cleaned borosilicate glass bottles will be used to collect samples for DOC analyses. Samples will be collected at a depth of approximately 1 foot. For the duration of each sampling event, water will be collected every thirty minutes using a pre-cleaned polyethylene collection bucket. Equal amounts of all samples (250 mL) will be combined into one large Erlenmeyer flask and stored on ice. At the end of the sampling period, the Erlenmeyer flask will be swirled to mix its contents and single, time-composite samples for TSS and DOC analyses will be collected in the appropriate containers. Samples for DOC will be filtered with a 45 μm syringe filter and sulfuric acid will be added to the bottle until pH is less than or equal to 2. Each DOC sample will be tested with pH-sensitive paper after acid is added to ensure that the pH meets the preservation requirements. TPH samples will be poured in 40 mL vials containing HCl; care will be taken not to leave any headspace. Duplicate samples will be sealed and carried in ice chests from the point of collection to the UH field office, where the samples will be placed in a refrigerator and kept at 4^{o}C or less. Twice a week, the samples will be packed in ice chests and delivered to Xenco laboratories. The laboratory data manager will receive a copy of the field log format and will log in the samples at the laboratory including both time of collection and time of receipt of each sample, as well as the temperature measured. pH measurements will be taken from the samples to be analyzed for DOC, and the values will be recorded in the logbook; if pH exceeds 2, the sample will be discarded. Samples will then be transferred to the cold room and stored at a temperature less than or equal to 4^{o}C.

Laboratory sample handling, custody, and storage procedures are described in the laboratories' (Maxxam Analytics and Xenco) quality assurance manuals (QAMs). A copy of the laboratories' QAMs will be on file at the University of Houston.

Failures in Chain-of-Custody and Corrective Action

All failures associated with chain-of-custody procedures as described in this QAPP are immediately reported to the University of Houston Project Manager. These include such items as delays in transfer, resulting in holding time violations; violations of sample preservation requirements; incomplete documentation, including signatures; possible tampering of samples; broken or spilled samples, etc. The University of Houston Project Manager in consultation with the Project QAO will determine if the procedural violation may have compromised the validity of the resulting data. Any failures that have reasonable potential to compromise data validity will invalidate data, and the sampling event should be repeated. The resolution of the situation will be reported to the TCEQ TMDL Project Manager in the project progress report. Corrective action reports will be prepared by the Project QAO and submitted to TCEQ TMDL Project Manager along with project progress report.

B4 ANALYTICAL METHODS

The analytical methods are listed in Table A7.1 of Section A7. Procedures for laboratory analysis will be in accordance with the most recently published edition of *Standard Methods for the Examination of Water and Wastewater*, the latest version of the TCEQ *Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue* (2003), *Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data* (2005), 40 CFR 136, or other reliable procedures acceptable to TCEQ. All the analytical methods to be used in this project have been approved by EPA.

Laboratories collecting data under this QAPP are, at minimum, compliant with the NELAC Standard. Copies of laboratory QAMs and SOPs are retained by the University of Houston and are available for review by the TCEQ. Laboratory SOPs are consistent with EPA requirements as specified in the method.

Standards Traceability

All standards used in the field and laboratory are traceable to certified reference materials. Standards preparation is fully documented and maintained in a standards log book. Each documentation includes information concerning the standard identification, starting materials, including concentration, amount used and lot number, date prepared, expiration date and preparer's initials or signature. The reagent bottle will be labeled in a way that will trace the reagent back to preparation.

Analytical Method Modification

Only data generated using approved analytical methodologies as specified in this QAPP will be submitted to the TCEQ. Requests for method modifications will be documented on form TCEQ-10364, the *TCEQ Application for Analytical Method Modification*, and submitted for approval to the TCEQ Quality Assurance Section. Work will only begin after the modified procedures have been approved.

Failures in Measurement Systems and Corrective Actions

Failures in field and laboratory measurement systems involve, but are not limited to such things as instrument malfunctions, failures in calibration, blank contamination, quality control samples outside QAPP defined limits, etc. In many cases, the field technician or lab analyst will be able to correct the problem. If the problem is resolvable by the field technician or lab analyst, then they will document the problem on the field data sheet or laboratory record and complete the analysis. If the problem is not resolvable, then it is conveyed to the Laboratory Supervisor, who will make the determination and notify the Project QAO. If the analytical system failure may compromise the sample results, the resulting data will not be reported to the TCEQ as part of this study. The nature and disposition of the problem is reported on the data report which is sent to the University of Houston Project Manager. The University of Houston Project Manager will include this information in the CAR and submit with the Progress Report which is sent to the TCEQ TMDL Project Manager.

Corrective Action Reports (CARs) document: root cause(s); programmatic impact(s); specific corrective action(s) to address any deviations; action(s) to prevent recurrence; individual(s) responsible for each action; the timetable for completion of each action; and the means by which completion of each corrective action will be documented. In addition, significant conditions (i.e., situations which, if uncorrected, could have a serious effect on safety or on the validity or integrity of data) will be reported to the TCEQ immediately both verbally and in writing.

B5 QUALITY CONTROL

Sampling Quality Control Requirements and Acceptability Criteria

The minimum Field QC Requirements are outlined in the *TCEQ Surface Water Quality Monitoring Procedures Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment and Tissue* (2003) and *Volume 2: Methods for Collecting and Analyzing Biological Community and Habitat Data* (2005). Specific requirements are outlined below. Field QC samples are reported with the laboratory data report (See Section A9 and C2).

Field Equipment Blanks – A field equipment blank is a sample of analyte-free media which has been used to rinse common sampling equipment to check the effectiveness of decontamination procedures. It is collected in the same type of container as the environmental sample, preserved in the same manner and analyzed for the same parameter. The analysis of equipment blanks should yield values lower than the LOQ. When target analyte concentrations are very high, blank values must be less then 5% of the lowest value of the batch or corrective action will be implemented.

Field duplicates - A field duplicate is defined as a second sample (or measurement) from the same location, collected in immediate succession, using identical techniques. This applies to all cases of routine surface water collection procedures, including in-stream grab samples, bucket grab samples (e.g., from bridges), pumps, and other water sampling devices as well as to tissue sample collection. Field duplicates for the high-volume sampling technique will be collected by using co-located samplers during the same sampling period.

Duplicate samples are sealed, handled, stored, shipped, and analyzed in the same manner as the primary sample. Precision of duplicate results is calculated by the relative percent deviation (FRPD) as defined by 100 times the difference (range) of each duplicate set, divided by the average value (mean) of the set. For duplicate results, X_1 and X_2, the FRPD is calculated from the following equation:

$$\mathbf{FRPD = \{ (X_1 - X_2) / [(X_1+X_2)/2] \} * 100}$$

Field duplicates for water and sediment will be collected at a frequency of 5% or greater and submitted to Maxxam Analytics and Xenco Laboratory in accordance with the procedures presented in Section B3. Due to the heterogeneous nature of the sampling in this project, the allowable FRPD between field duplicates will be 50%.

Field Blanks - A field blank is prepared in the field by filling a clean container with pure deionized water and appropriate preservative, if any, for the specific sampling activity being undertaken. They are used to assess the contamination from field sources such as airborne materials, containers, and preservatives. The analysis of field blanks should yield values lower than the LOQ. When target analyte concentrations are high, blank values should be less then 5% of the lowest value of the batch.

For the high-volume water samples, the field blanks will consist of an uninstalled resin bed and a filter that will travel with the sampling team. It will be packed and placed in the coolers with the collected samples for analysis after the sampling event.

For sediment, the field blank will consist of clean playground sand (previously baked at 400 degrees C to remove the organics, and then re-wetted) that will travel with the sampling team and will be analyzed with the collected samples.

Field blanks will be collected at a frequency of 5% or greater.

Laboratory Measurement Quality Control Requirements and Acceptability Criteria

Method Specific QC requirements – QC samples, other than those specified later this section, are run (e.g., sample duplicates, surrogates, internal standards, continuing calibration samples, interference check samples, positive control, negative control, and media blank) as specified in the methods. The requirements for these samples, their acceptance criteria or instructions for establishing criteria, and corrective actions are method-specific.

Detailed laboratory QC requirements are contained within each individual method and laboratory Quality Assurance Manuals. The minimum requirements that all participants abide by are stated below. Lab QC sample results are reported with the data report (see Section C2 and A9).

Limit of Quantitation (LOQ) – The laboratory will analyze a calibration standard (if applicable) at the LOQ on each day TMDL Program samples are analyzed. Calibrations including the standard at the LOQ will meet the calibration requirements of the analytical method or corrective action will be implemented.

> LOQ Sediment and Tissue Samples – When considering LOQs for solid samples and how they apply to results, two aspects of the analysis are considered: (1) the LOQ of the sample, based on the real-world in which moisture content and interferences affect the result and (2) the LOQ in the QAPP which is a value less than or equal to the AWRL based on an idealized sample with zero % moisture.
>
> The LOQ for a solid sample is based on the lowest non-zero calibration standard (as are those for water samples), the moisture content of the solid sample, and any sample concentration or dilution factors resulting from sample preparation or clean-up.
>
> To establish solid-phase LOQs to be listed in Table A7.1 of the QAPP, the laboratory will adjust the concentration of the lowest non-zero calibration standard for the amount of sample extracted, the final extract volume, and moisture content (assumed to be zero % moisture). Each calculated LOQ will be less than or equal to the AWRL on the dry-weight basis to satisfy the AWRL requirement for sediment and tissue analyses. When data are reviewed for consistency with the QAPP, they are evaluated based on this requirement. Results may not appear to meet the AWRL requirement due to high moisture content, high concentrations of non-target analytes necessitating sample

dilution, etc. These sample results will be submitted to the TCEQ with an explanation on the data summary as to why results do not appear to meet the AWRL requirement.

LOQ Check Standard – An LOQ check standard consists of a sample matrix (e.g., deionized water, sand, commercially available tissue) free from the analytes of interest spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is used to establish intra-laboratory bias to assess the performance of the measurement system at the lower limits of analysis. The LOQ check standard is spiked into the sample matrix at a level less than or near the LOQ for each analyte for each batch of TMDL samples are run.

The LOQ check standard is carried through the complete preparation and analytical process. LOQ Check Standards are run at a rate of one per analytical batch. A batch is defined as samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples.

The percent recovery of the LOQ check standard is calculated using the following equation in which %R is percent recovery, SR is the sample result, and SA is the reference concentration for the check standard:

$$\%R = SR/SA * 100$$

Measurement performance specifications are used to determine the acceptability of LOQ Check Standard analyses as specified in Table A7.1.

Laboratory Control Sample (LCS) - An LCS consists of a sample matrix (e.g., deionized water, sand, commercially available tissue) free from the analytes of interest spiked with verified known amounts of analytes or a material containing known and verified amounts of analytes. It is used to establish intra-laboratory bias to assess the performance of the measurement system. The LCS is spiked into the sample matrix at a level less than or near the mid point of the calibration for each analyte. In cases of test methods with very long lists of analytes, LCSs are prepared with all the target analytes and not just a representative number, except in cases of organic analytes with multipeak responses.

The LCS is carried through the complete preparation and analytical process. LCSs are run at a rate of one per analytical batch. A batch is defined as samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples.

Results of LCSs are calculated by percent recovery (%R), which is defined as 100 times the measured concentration, divided by the true concentration of the spiked sample.

The following formula is used to calculate percent recovery, where %R is percent recovery; SR is the measured result; and SA is the true result:

$$\%R = SR/SA * 100$$

Measurement performance specifications are used to determine the acceptability of LCS analyses as specified in Table A7.1.

Laboratory duplicate – A laboratory duplicate is prepared by taking aliquots of a sample from the same container under laboratory conditions and processed and analyzed independently. A laboratory control sample duplicate (LCSD) is prepared in the laboratory by splitting aliquots of an LCS. Both samples are carried through the entire preparation and analytical process. LCSDs are used to assess precision and are performed at a rate of one per batch. A batch is defined as samples that are analyzed together with the same method and personnel, using the same lots of reagents, not to exceed the analysis of 20 environmental samples. For most parameters, precision is calculated by the relative percent difference (RPD) of LCS duplicate results as defined by 100 times the difference (range) of each duplicate set, divided by the average value (mean) of the set. For duplicate results, X_1 and X_2, the RPD is calculated from the following equation:

$$RPD = (X_1 - X_2)/\{(X_1+X_2)/2\} * 100$$

Measurement performance specifications are used to determine the acceptability of duplicate analyses-as specified in Table A7.1.

Method Blank- A method blank is a sample of matrix similar to the batch of associated samples (when available) that is free from the analytes of interest and is processed simultaneously with and under the same conditions as the samples through all steps of the analytical procedures, and in which no target analytes or interferences are present at concentrations that impact the analytical results for sample analyses. The method blank is carried through the complete sample preparation and analytical procedure. The method blank is used to document contamination from the analytical process. The analysis of method blanks should yield values less than the LOQ. For very high-level analyses, the blank value should be less then 5% of the lowest value of the batch, or corrective action will be implemented.

Failures in Quality Control and Corrective Action

Sampling QC excursions are evaluated by the University of Houston Project Manager, in consultation with the Project QAO. In that differences in sample results are used to assess the entire sampling process, including environmental variability, the arbitrary rejection of results based on pre-determined limits is not practical. Therefore, the professional judgment of the University of Houston Project Manager and Project QAO will be relied upon in evaluating results. Rejecting sample results based on wide variability is a possibility. Field blanks for trace elements and trace organics are scrutinized very closely. Field blank values exceeding the acceptability criteria may automatically invalidate the sample, especially in cases where high blank values may be indicative of contamination which may be causal in putting a value above the standard. Notations of field split excursions and blank contamination are noted in the quarterly report and the final QC Report. Equipment blanks for metals analysis are also scrutinized very closely.

Corrective action will involve identification of the cause of the failure where possible. Response actions will typically include re-analysis of questionable samples. In some cases, a site may have to be re-sampled to achieve project goals.

Laboratory measurement quality control failures are evaluated by the laboratory staff. The disposition of such failures and the nature and disposition of the problem is reported to the Laboratory QAO. The Laboratory QAO will discuss with the University of Houston Project Manager. If applicable, the University of Houston Project Manager will include this information in the CAR and submit with the Progress Report which is sent to the TCEQ TMDL Project Manager.

Corrective Action Reports (CARs) document: root cause(s); programmatic impact(s); specific corrective action(s) to address any deviations; action(s) to prevent recurrence; individual(s) responsible for each action; the timetable for completion of each action; and the means by which completion of each corrective action will be documented. In addition, significant conditions (i.e., situations which, if uncorrected, could have a serious effect on safety or on the validity or integrity of data) will be reported to the TCEQ immediately both verbally and in writing.

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

All sampling equipment testing and maintenance requirements for water and tissue samples are detailed in the *TCEQ Surface Water Quality Monitoring Procedures Manual*. Maintenance requirements for the high-volume sampling equipment are detailed in the SOP. Equipment records are kept on all field equipment and a supply of critical spare parts is maintained by the Project Field Supervisor, or designee.

All laboratory tools, gauges, instrument, and equipment testing and maintenance requirements are contained within laboratory QAM(s). Instruments requiring daily or in-use testing may include, but are not limited to, water baths, ovens, autoclaves, incubators, refrigerators, and laboratory pure water. Critical spare parts for essential equipment are maintained to prevent downtime. Testing and maintenance records are available for inspection by the TCEQ.

B7 INSTRUMENT/EQUIPMENT CALIBRATION AND FREQUENCY

Field equipment calibration requirements are contained in the TCEQ *Surface Water Quality Monitoring Procedures*. Post calibration error limits and the disposition resulting from error are adhered to. Data not meeting post-error limit requirements invalidates associated data collected subsequent to the pre-calibration and are not submitted to the TCEQ.

Detailed laboratory calibrations are contained within the QAM(s). The laboratory QAM identifies all tools, gauges, instruments, and other sampling, measuring, and test equipment used for data collection activities affecting quality that must be controlled and, at specified periods, calibrated to maintain bias within specified limits. Calibration records are maintained, are traceable to the instrument, and are available for inspection by the TCEQ. Equipment requiring periodic calibrations include, but are not limited to, thermometers, pH meters, balances, incubators, turbidity meters, and analytical instruments.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Field supplies are visually inspected and tested before use to ensure adequacy. All new batches of field and laboratory supplies are inspected and tested before use to ensure that they are adequate and not contaminated. The laboratory QAM provides additional details on acceptance requirements for laboratory supplies and consumables.

Copies of the laboratories' QAMs will be on file at the University of Houston.

B9 NON-DIRECT MEASUREMENTS

Only data collected directly under this QAPP will be submitted to the SWQMIS database. Sampling conducted by the TCEQ, the USGS, and Texas Clean Rivers Program partners is not covered under this QAPP and will not be reported to the TMDL Data Manager by the University of Houston. However, data collected by the above organizations that meet the data quality objectives of this project may be useful in satisfying the data and informational needs of the TMDL. The collection and qualification of the TCEQ and USGS data are addressed in the TCEQ Surface Water Quality Monitoring QAPP. The collection and qualification of the Texas CRP data are addressed in the Texas Clean Rivers Program QAPP.

Stream flow data collected by the USGS may be used to assist in estimating loads of PCBs. These data will be obtained from the USGS web site. These data are considered provisional for some time after their collection, generally until the publication of the annual water summary. Because the intended use of the data is only to explore the potential magnitude of PCB loads in runoff, these data will be satisfactory. If the USGS data were to be used to set permit limits or load allocations, the flow measurements must be verified and validated with the USGS.

Rain gauge data from the Harris County Flood Control District, Harris County Office of Emergency Management, and the City of Houston will be used to aid in assessing loads of PCBs in storm water. These data are not covered by this QAPP and will not be reported to TCEQ.

Only data collected directly under this QAPP will be submitted to the SWQMIS database.

B10 DATA MANAGEMENT

For each sampling event, the University of Houston will provide documentation of data management efforts for field data, laboratory results, and general sampling event information for water and tissue samples in accordance with the guidelines established by TCEQ in the *Surface Water Quality Monitoring Data Management Reference Guide* and consistent with this QAPP (see the Data Review Checklist in Appendix F). The data management efforts may include, but are not limited to: new station identifier requests, new parameter code requests, new submitting entity/collecting entity codes, monitoring type codes, tag prefix requests, data review procedures, data reporting procedures, data correction procedures, and participation in data management training and quality assurance audits.

Data Management Protocols for the above noted sample types are addressed in the Data Management Plan which is in Appendix E of the document.

References

TCEQ, 2007, or most recent version: *Surface Water Quality Monitoring Data Management Reference Guide.* http://www.tceq.state.tx.us/compliance/monitoring/water/quality/data/wdma/dmrg_index.html

TCEQ, 2003. *Surface Water Quality Monitoring Procedures Manual, Volume 1: Physical and Chemical Monitoring Methods for Water, Sediment, and Tissue.* RG-415, December 2003.

Warning: When references are made to documents that are not attached to the QAPP, the University of Houston Project Manager/QAO should assume responsibility for compliance of the documentation with the procedures and requirements set forth in the QAPP.

C1 ASSESSMENTS AND RESPONSE ACTIONS

The following table presents types of assessments and response action for data collection activities applicable to the QAPP.

Table C1.1 Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
Status Monitoring Oversight, etc.	Continuous	U of H PM	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of contract laboratory performance and data quality	Report to TCEQ in Quarterly Report. Ensure project requirements are being fulfilled.
Laboratory Inspections	Dates to be determined by the TCEQ lab inspector	TCEQ Laboratory Inspector	Analytical and quality control procedures employed at the laboratory and the contract laboratory	30 days to respond in writing to the TCEQ to address corrective actions
	Annually	Lab QAO		Implements corrective action. Inspection report will be available for review by TCEQ
Monitoring Systems Audit	Dates to be determined by TCEQ	TCEQ QAS	Field sampling, handling and measurement; facility review; and data management as they relate to the TMDL Project	30 days to respond in writing to the TCEQ to address corrective actions
	Annually	Project QAO		Report sent to TCEQ PM. Resolves any deficiencies.

Corrective Action

The University of Houston Project Manager is responsible for implementing and tracking corrective action procedures as a result of audit findings. Records of audit findings and corrective actions are maintained by the TCEQ TMDL Project Manager and University of Houston Project Manager and/or the Project Quality Assurance Officer. Corrective action documentation will be submitted to the TCEQ TMDL Project Manager with the progress report.

If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work is specified in agreements or contracts between participating organizations.

C2 REPORTS TO MANAGEMENT

Laboratory Data Reports

Laboratory data reports contain the results of all specified QC measures listed in section B5, including but not limited to field equipment blanks, trip blanks, field blanks, laboratory duplicates, field splits, laboratory control standards, matrix spikes, AWRL/LOQ verification, laboratory equipment blanks, and method blanks. This information is reviewed by the Project QAO and compared to the pre-specified acceptance criteria to determine acceptability of data before forwarding to the University of Houston Project Manager. This information is available for inspection by the TCEQ.

Reports to University of Houston Project Management

Parsons will submit to the University of Houston Project Manager periodic information regarding project status, results of assessments (including data), and significant QA issues to management. These reports will be submitted in electronic format.

Reports to TCEQ Project Management

All reports detailed in this section are contract deliverables and are transferred to the TCEQ in accordance with contract requirements.

Quarterly Progress Report - Summarizes the University of Houston/Parsons activities for each task, reports problems, delays, and corrective actions; and outlines the status of each task's deliverables.

Monitoring Systems Review Audit Report/Laboratory Audit Report and Response - Following any audit performed by the University of Houston, a report of findings, recommendations and responses are sent to the TCEQ project manager in the quarterly/monthly progress report.

Reports by TCEQ Project Management

Contractor Evaluation – The University of Houston is evaluated in a Contractor Evaluation by the TCEQ annually for compliance with administrative and programmatic standards. Results of the evaluation are submitted to the TCEQ Financial Administration Division, Procurements and Contracts Section.

D1 DATA REVIEW, VERIFICATION AND VALIDATION

For the purposes of this document, verification refers to the processes taken to determine compliance of data with project requirements, including documentation and technical criteria. Validation means those processes taken independently of the data-generation processes to determine the usability of data for its intended use(s). Integrity means the processes taken to assure that no falsified data will be reported.

All data obtained from field and laboratory measurements will be reviewed and verified for conformance to project requirements, and then validated against the data quality objectives which are listed in Section A7. Only those data which are supported by appropriate quality control data and meet the data quality objectives defined for this project will be considered acceptable. This data will be submitted to the TCEQ for entry into the SWQMIS database.

The procedures for verification and validation of data are described in Section D2, below. The Project Field Supervisor is responsible for ensuring that field data are properly reviewed and verified for integrity. The Laboratory Supervisor is responsible for ensuring that laboratory data are scientifically valid, defensible, of acceptable precision and accuracy, and reviewed for integrity. The Project Data Manager will be responsible for ensuring that all data are properly reviewed and verified, and submitted in the required format as described in the latest version of the SWQM Data Management Reference Guide (2007) to the TCEQ Project Manager. The Project QAO is responsible for validating the data. Finally, the University of Houston Project Manager, with the concurrence of the Project QAO, are responsible for validating that all data to be reported meet the objectives of the project and are suitable for reporting to TCEQ.

D2 VERIFICATION AND VALIDATION METHODS

All field and laboratory data will be reviewed, verified and validated to ensure they conform to project specifications and meet the conditions of end use as described in Section A7. The staff and management of the respective field, laboratory, and data management tasks are responsible for the integrity, validation and verification of the data each task generates or handles throughout each process. The field and laboratory tasks ensure the verification of raw data, electronically generated data, and data on chain-of-custody forms and hard copy output from instruments.

Data verification, validation and integrity review of data will be performed using self-assessments and peer review, as appropriate to the project task, followed by technical review by the manager of the task. The data to be verified (listed by task in Table D2.1) are evaluated against project specifications (Section A7) and are checked for errors, especially errors in transcription, calculations, and data input. Potential outliers are identified by examination for unreasonable data, or identified using computer-based statistical software. If a question arises or an error or potential outlier is identified, the manager of the task responsible for generating the data is contacted to resolve the issue. Issues which can be corrected are corrected and documented electronically or by initialing and dating the associated paperwork. If an issue cannot be corrected, the task manager consults with higher level project management to establish the appropriate course of action, or the data associated with the issue are rejected. The performance of these tasks is documented by completion of the data review checklist (Appendix F) by the Project Data Manager.

The University of Houston Project Manager and QAO are each responsible for validating that the verified data are scientifically valid, legally defensible, of known precision, accuracy, integrity, meet the data quality objectives of the project, and are reportable to TCEQ. One element of the validation process involves evaluating the data again for anomalies. The Project QAO or Project Manager may designate other experienced water quality experts familiar with the water bodies under investigation to perform this evaluation. Any suspected errors or anomalous data must be addressed by the manager of the task associated with the data, before data validation can be completed.

A second element of the validation process is consideration of any findings identified during the monitoring systems audit conducted by the Project QAO or TCEQ QAS assigned to the project. Any issues requiring corrective action must be addressed, and the potential impact of these issues on previously collected data will be assessed. Finally, the Univresity of Houston Project Manager, with the concurrence of the QAO validates that the data meet the data quality objectives of the project and are suitable for reporting to TCEQ.

Table D2.1 Data Verification Procedures

Tasks	**Responsible Entity/Individual**
Field Data Review	
Field data reviewed for conformance with data collection procedures, sample handling and chain of custody, analytical and QC requirements	UH/Parsons
Post calibrations checked to ensure compliance with error limits	UH/Parsons
Field data calculated, reduced, and transcribed correctly	UH/Parsons
Laboratory Data Review	
Laboratory data reviewed for conformance for conformance with data collection, sample handling and chain of custody, analytical and QC requirements to include documentation, holding times, sample receipt, sample preparation, sample analysis, project and program QC results, and reporting	Project QAO
Laboratory data calculated, reduced, and transcribed correctly	Project QAO
LOQs consistent with requirements for AWRLs	Project QAO
Analytical data documentation evaluated for consistency, reasonableness and/or improper practices	Project QAO
Analytical QC information evaluated to determine impact on individual analyses	Project QAO
All laboratory samples analyzed for all parameters	Project QAO
Data Set Review	
The test report has all required information as described in Section A9 of the QAPP	Project Data Manager
Confirmation that field and lab data have been reviewed	Project Data Manager

Tasks	**Responsible Entity/Individual**
Data set (to include field and laboratory data) evaluated for reasonableness and if corollary data agree	Project Data Manager
Outliers confirmed and documented	Project Data Manager
Field QC acceptable (e.g., field splits and trip, field and equipment blanks)	Project Data Manager
Sampling and analytical data gaps checked and documented	Project Data Manager
Verification and validation confirmed. Data meets conditions of end use and are reportable	Project Project Manager

D3 RECONCILIATION WITH USER REQUIREMENTS

No decisions will be made by the project team based on the data collected. These data, and data collected by other organizations (e.g., DSHS, USGS, TCEQ, etc.), may be subsequently analyzed and used by the TCEQ for TMDL development, stream standards modifications, permit decisions, and water quality assessments. Data which do not meet requirements will not be submitted to the SWQMIS database nor will be considered appropriate for any of the uses noted above.

APPENDIX A
WORK PLAN

APPENDIX A. WORK PLAN

Description of the Project

Polychlorinated biphenyls (PCBs) are widespread organic contaminants that are environmentally persistent and can be harmful to human health even at low concentrations. A major route of exposure for PCBs worldwide is through food consumption, and this route is especially significant in seafood. The discovery of PCBs in seafood tissue has led the Texas Department of State Health Services to issue seafood consumption advisories, and some of these advisories have been issued for the Houston Ship Channel (HSC). Two specific advisories have been issued recently for all finfish species based on concentrations of PCBs, organochlorine pesticides, and dioxins. ADV-20 was issued in October 2001 and includes the HSC upstream of the Lynchburg Ferry crossing and all contiguous waters, including the San Jacinto River Tidal below the U.S. Highway 90 bridge. ADV-28 was issued in January 2005 for Upper Galveston Bay (UGB) and the HSC and all contiguous waters north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. These two advisories represent a large surface water system for which TMDLs need to be developed and implemented.

In total, the consumption advisories for PCBs cover all or part of designated water quality segments 0901 Cedar Bayou Tidal, 1001 San Jacinto River Tidal, 1005 Houston Ship Channel/San Jacinto River Tidal, 1006 Houston Ship Channel Tidal, 1007 Houston Ship Channel/Buffalo Bayou Tidal, 2430 Burnett Bay, 2429 Scott Bay, 2428 Black Duck Bay, 2427 San Jacinto Bay, 2426 Tabbs Bay, 2436 Barbours Cut, 2438 Bayport Channel, and 2421 Upper Galveston Bay. All parts of those segments that are covered by the PCB consumption advisories will comprise the project area. The overall purpose of this project is to develop a total maximum daily load (TMDL) allocation for PCBs in the Houston Ship Channel System, including upper Galveston Bay, and a plan for managing PCBs to correct existing water quality impairments and maintain good water quality in the future.

Monitoring and Data Collection

Sediment, water, and fish would be sampled. Crab would not be sampled since previous data from summer 2002, fall 2002, and spring 2003 indicated that levels were below standards for crabs in all segments. Air sampling and air deposition studies may be undertaken based on the results from the source assessment work that is on-going at this time.

Target tissue species. Wherever possible, two fish species will be sampled at a single location: speckled seatrout (the species included in the advisory) and catfish (preferably hardhead). Each sample will consist of edible tissue from 3-5 individuals.

Congeners. All 209 PCB congeners will be quantified across the various media.

Parameters other than PCBs. For sediment: TOC, TPH. For water: TSS, DOC, POC, TPH, Salinity, Specific Conductivity, and Temperature. For fish: percent lipids.

Flow sampling will be undertaken at selected stations: 11347 (Buffalo Bayou at Main Street), 16873 (Patrick Bayou Upstream of WWTP), 11200 (San Jacinto River Tidal at US90), 11175 (or TBD99 – Upstream Carpenters Bayou) and 11272 (Carpenters Bayou at Sheldon Rd).

Data Objectives. The objectives for sampling for PCBs for the three media in the Channel include:

- Provide a current snapshot of PCB concentrations in sediment, fish and water in the Channel.
- Minimize the number of sampled stations with non-detect concentrations.
- Maximize the number of sampled stations that have been sampled previously to obtain a temporal understanding of PCB behavior in the system.
- Sample stations that have historically exhibited high concentrations in any medium.
- Maximize the number of samples where all three media are sampled concurrently to allow comparisons among the media.
- Consider the presence of potential sources in station selection.
- Water concentrations at the mouth of major tributaries (non-tidal) would be measured to allow load estimation (using flow from USGS gage for the trib). The concentrations would be measured in dry and wet-weather conditions.
- Ambient concentrations in the channel for the three media would be sampled during warm and cold weather to assess temperature effects, if any.
- Undertake extensive localized surveys in sediment and water in areas that exhibit high PCB concentrations and in areas that might be experiencing precipitation of suspended or dissolved materials due to the fresh/saline interface between tidal and non-tidal conditions.

Sampling Sites. The selected sampling sites and frequency of sampling are presented in Table 2 and Figure 2 of Appendix B.

Sources Sampling. Up to 20 facilities that directly discharge to the Channel would be sampled for PCB in their discharge as well as in their runoff.

Data Analysis

The product of the sampling activities will be a quantification of PCBs in water, sediment, fish tissue, runoff, and effluent for the Houston Ship Channel System. The UH/Parsons Team will then be able to analyze data to assess current levels and loadings of PCBs and to evaluate potential sources of PCB contamination to the Houston Ship Channel. The collected data will ultimately be used to set-up and calibrate a water-sediment model to simulate the transport and fate of PCBs in the Houston Ship Channel.

Data Submittal

Most of the data collected under this QAPP will be appropriate for inclusion in the SWQMIS database as representing ambient conditions in water bodies, while other types of data (i.e., runoff and effluent data) will support project activities but will not become part of SWQMIS. Table 1 includes a list of data generated under this QAPP.

Table 1. Summary of Collected Data and Inclusion into SWQMIS

Parameter	In-stream Water	Bed Sediment	Tissue	Runoff	Effluent
TSS	Y	NA	NA	N	N
DOC	Y	NA	NA	N	N
TPH	Y	NA	NA	N	N
TOC	NA	Y	NA	NA	NA
Solids Content	NA	Y	NA	NA	NA
TPH	NA	Y	NA	NA	NA
Lipid content	NA	NA	Y	NA	NA
PCB dissolved in water	Y	NA	NA	N	N
PCB in suspended sediment	Y	NA	NA	N	N
PCB in sediment	NA	Y	NA	NA	NA
PCB in fish tissue	NA	NA	Y	NA	NA

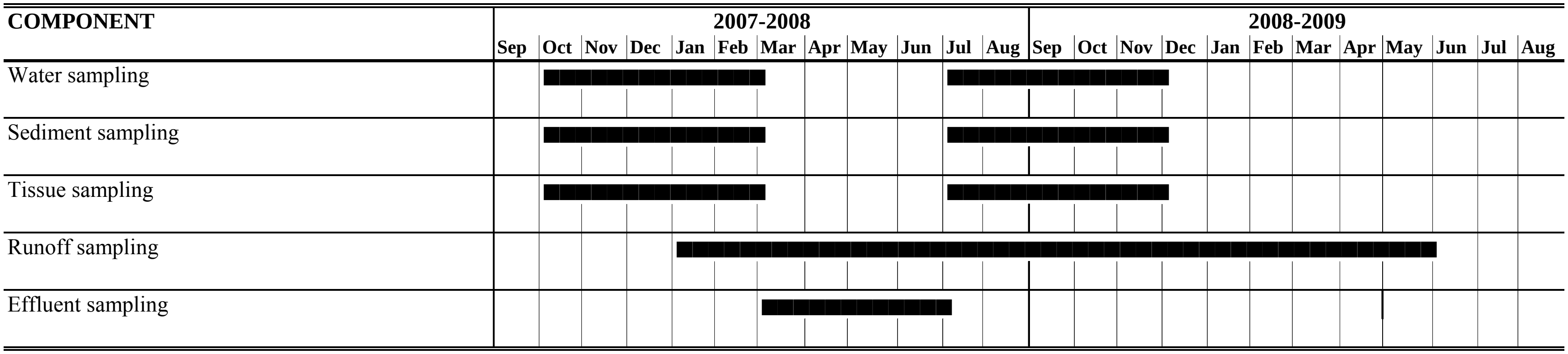
Y = data will be included into SWQMIS; N = data will not be included into SWQMIS; NA = not applicable (parameter will not be measured)

Appendix E outlines the requirements for data submittal to the SWQMIS database.

Schedule

Sampling is expected to begin in October 2007 and will continue for 21 months. A report describing sampling and analytical procedures and results will be prepared two months after testing is finished or as specified in the approved work order. Figure 1 depicts the proposed timeline for the work to be completed under this QAPP.

Figure 1 – Monitoring Plan Time Line



APPENDIX B
SAMPLING PROCESS DESIGN AND MONITORING SCHEDULE

APPENDIX B. SAMPLING PROCESS DESIGN AND MONITORING SCHEDULE

Sample Design Rationale

The sample design is based on the program requirements of the Total Maximum Daily Load Program. The TCEQ, and the University of Houston through contract with the TCEQ, has been tasked with providing data and information to characterize water quality conditions, to identify the presence or absence of impairments of designated water body uses, and to support water quality modeling, site-specific water quality standard revisions, the load allocation, and other TMDL data and information needs. The environmental data collected under this QAPP must be collected and evaluated with a high degree of confidence that the data are scientifically valid, of known quality, and legally defensible. As part of the TMDL stakeholder involvement process, the University of Houston coordinates closely with the TCEQ and other TMDL participants to ensure an adequate water monitoring strategy to supply informational needs for modeling, assessment, load allocation, and decision-making. Also see Appendix A for more information about the sample design and rationale.

Site Selection Criteria

This data collection effort involves monitoring “in-stream” water quality data for the purpose of aiding TMDL development and for entry into the SWQMIS database, which is maintained by the TCEQ. In addition, runoff and effluent samples will be collected to assess the contribution of current sources to the in-stream PCB loading. Runoff and effluent data do not represent ambient conditions and, therefore, will not be submitted to the SWQMIS database. The general guidelines included below were followed when selecting sampling sites. Overall consideration was given to accessibility and safety. All monitoring activities have been developed in coordination with the TMDL Stakeholder Committee and with the TCEQ TMDL Project Manager.

- Monitoring sites are representative of in-stream data and are free from back-water effects.
- Monitoring sites are selected to maximize stream coverage or basin coverage. For very long stretches of stream length, a station is considered representative of a water body for not more than 25 miles in freshwater and tidal streams. A single monitoring site is considered representative of 25 percent of the total reservoir acres and estuary or ocean square miles, but not more than 5,120 acres or 8 square miles.
- Monitoring sites are located preferentially where there are “localized” water quality effects based on past water quality data.
- Monitoring sites are located where historical data exists. No degradation of water quality may be indicated. However, the continuation of water quality monitoring at this site has been deemed important.
- At least one site for each classified segment will be selected for fixed/routine monitoring unless the segment is already covered by TCEQ or other qualified monitoring entities reporting fixed/routine data to TCEQ.
- Monitoring sites may be selected to bracket sources of pollution, influence of tributaries, changes in land uses, and hydrological modifications.

- Monitoring sites are chosen based on accessibility. When possible, sites are selected where it is possible to collect flow measurements during routine visits or where a stream flow gage is located.

All sites will be visited prior to sampling to determine access, identify safety issues, and to deploy stage markings for later use (this could be spray-paint markings, staff installation or the like). Permissions from the appropriate local jurisdictions will be obtained for access and for lane closures (if needed) prior to site reconnaissance or sampling activity.

Monitoring Sites

The monitoring plan consists of collecting 74 high-volume water samples, 50 bottom sediment samples, and up to 100 tissue samples to confirm the severity and spatial extent of the current impairment. In addition, the monitoring plan includes collection of samples at 20 wastewater dischargers and at 14 stormwater locations to aid in calculating pollutant loads. Table 2 presents monitoring sites and frequencies for fiscal years 2008 and 2009 (September 1, 2007 to August 31, 2009) included as part of this project QAPP. Figure 2 shows the locations of the sampling sites.

Critical vs. non-critical measurements

All data collected for the TCEQ TMDL Program, whether entered into the SWQMIS database or not, are considered critical.

Table 2. Monitoring Sites and Frequencies

Basin: San Jacinto River Basin
Segment ID: 0901, 1001, 1005, 1006, 2430, 2429, 2428, 2427, 2426, 2436, 2438, and 2421
TCEQ Region 12
Fiscal Years 2008-2009 (September 1, 2007 to August 31, 2009)

Station ID	Description	Latitude	Longitude	Segment	SE	CE	MT	Monitoring frequencies for each parameter group										
								Field parameters[b]	TOC in sediment	TPH in sediment	TSS	TOC/ DOC in water	TPH in water	PCBs in water	PCBs in sediment	PCBs in tissue	PCBs in runoff	PCBs in effluent
11351	Buffalo Bayou at Sheppard Dr. (USGS 08074000)	29.760563	-95.408508	1007	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
11387	Whiteoak Bayou at Heights Blvd	29.775	-95.396942	1007	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
11347	Buffalo Bayou Tidal at Main St.	29.764723	-95.358887	1007	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11292	Houston Ship Channel/Buffalo Bayou in middle of Turning Basin	29.749166	-95.288887	1007	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11139	Brays Bayou at South Main St.	29.697258	-95.412033	1007	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
11132	Sims Bayou at Telephone Rd (USGS 08075500)	29.673922	-95.288979	1007	UH	UH/PE	RT/BF[a]	6	2	2	4	4	4	2	2	2	2	
11287	Houston Ship Channel/Buffalo Bayou at Confluence with Sims Bayou	29.719166	-95.2425	1007	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11171	Vince Bayou at W. Ellaine St. (USGS 08075730)	29.694443	-95.216278	1007	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
11129	Hunting Bayou at North Loop East (IH 610) in Houston	29.793167	-95.268288	1007	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
TBD-1	Small ditch discharging to Hunting Bayou	TBD	TBD	1007	UH	UH/PE	RT/BF[a]	2			2	2	2				2	
11280	Houston Ship Channel/Buffalo Bayou at Armco Steel Corporation Intake Screens	29.744444	-95.18972	1007	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11368	Greens Bayou at Brock Park	29.843056	-95.231392	1006	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
11274	Greens Bayou Tidal at Mechling Barge Lines. Alternatively, Greens Bayou at ISK Biosciences Ditch (station 16981)	29.753334	-95.175835	1006	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11270	Houston Ship Channel at CM 150	29.741112	-95.159164	1006	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
15979	Houston Ship Channel at Shell Barge Cut, 0.9 mi. downstream of Beltway 8	29.733938	-95.133171	1006	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
15936	HSC at OxyChem Ditch (005/004)	29.738806	-95.108307	1006	UH	UH/PE	RT	2			2	2	2	2				
11175	Carpenters Bayou Immediately Upstream of Loop 8 (Beltway) or a Freshwater Location TBD	29.772549	-95.156174	1006	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
17149	Patrick Bayou Upstream of Tidal Rd	29.733833	-95.114632	1006	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
17157	Patrick Bayou xxx	29.719778	-95.117172	1006	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
11264	Houston Ship Channel at at San Jacinto Park, West of Battleship Texas	29.755556	-95.091667	1006	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
16622	San Jacinto River Tidal at Banana Bend Road at end of pavement in Houston	29.845556	-95.10611	1001	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11193	San Jacinto River Tidal IH 10 Bridge East of Channelview	29.791945	-95.061386	1001	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
15301	Old River Tidal/HSC at Old River Ship Building, Near Lakeside Dr and N Shore Dr	29.774111	-95.101715	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11262	HSC Between Lynchburg Ferry and IH-10, 121m S AND 1.27km W of Lynchburg Rd and Lakeview Dr	29.780556	-95.075279	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		

Station ID	Description	Latitude	Longitude	Segment	SE	CE	MT	Monitoring frequencies for each parameter group										
								Field parameters[b]	TOC in sediment	TPH in sediment	TSS	TOC/ DOC in water	TPH in water	PCBs in water	PCBs in sediment	PCBs in tissue	PCBs in runoff	PCBs in effluent
11261	Houston Ship Channel San Jacinto River at Lynchburg Ferry	29.762777	-95.07917	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
13344	Burnett Bay at Mid-Bay	29.767778	-95.051392	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11258	Houston Ship Channel at CM 120	29.739721	-95.058891	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
13342	Scott Bay at Mid-Bay	29.743334	-95.040001	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
16618	Houston Ship Channel/San Jacinto River West of Exxon Docks and North of Alexander Island	29.728611	-95.028336	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
16499	San Jacinto Bay 200 yds SW of CM25 (98GB007)	29.709694	-95.055191	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
13340	Black Duck Bay at Mid-Bay	29.716667	-95.004723	1005	UH	UH/PE	RT	2			2	2	2	2				
13338	Tabbs Bay Midway Between Goose Creek and Upper Hog Island	29.703541	-94.990616	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
13355	Barbours Cut mid-way between mouth And terminus	29.681856	-94.999535	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
11252	Houston Ship Channel at CM 91, Morgan's Point	29.682777	-94.981941	1005	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
TBD-2	Cedar Bayou non-tidal	TBD	TBD	2421	UH	UH/PE	RT/BF[a]	4			4	4	4	2			2	
14560	Upper Galveston Bay at HSC Marker 75	29.606657	-94.952339	2421	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
13363	Bayport Channel mid-way between mouth and terminus	29.613386	-95.010551	2421	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
16213	Upper Galveston Bay at 97GB019, 5.25mi north of the HL&P P. H. Robinson Outfall	29.5445	-94.961166	2421	UH	UH/PE	RT	4	2	2	2	2	2	2	2	2		
TBD-3	Small ditch to obtain a direct runoff concentration in the eastern part of the channel	TBD	TBD	1005	UH	UH	BF	2			2	2	2				2	
TBD-4	Small ditch to obtain a direct runoff concentration in the eastern part of the channel	TBD	TBD	1006	UH	UH	BF	2			2	2	2				2	
TBD	Twenty WWTP locations to be determined	TBD	TBD	TBD	UH	UH	BF	1			1(20)[c]	1(20)[c]						1(20)[c]

[a] RT for ambient conditions (i.e. in-stream water, tissue, and sediment samples) and BF for non-ambient conditions (i.e. runoff and effluent samples)

[b] Field parameters: temperature, pH, conductivity, and salinity

[c] Sampling will occur at 20 locations, one time each

TBD - to be determined, SLOC requests will be submitted to TCEQ. For effluent samples, a list of twenty facilities (with TPDES permit numbers) will be submitted to TCEQ for approval prior to sampling

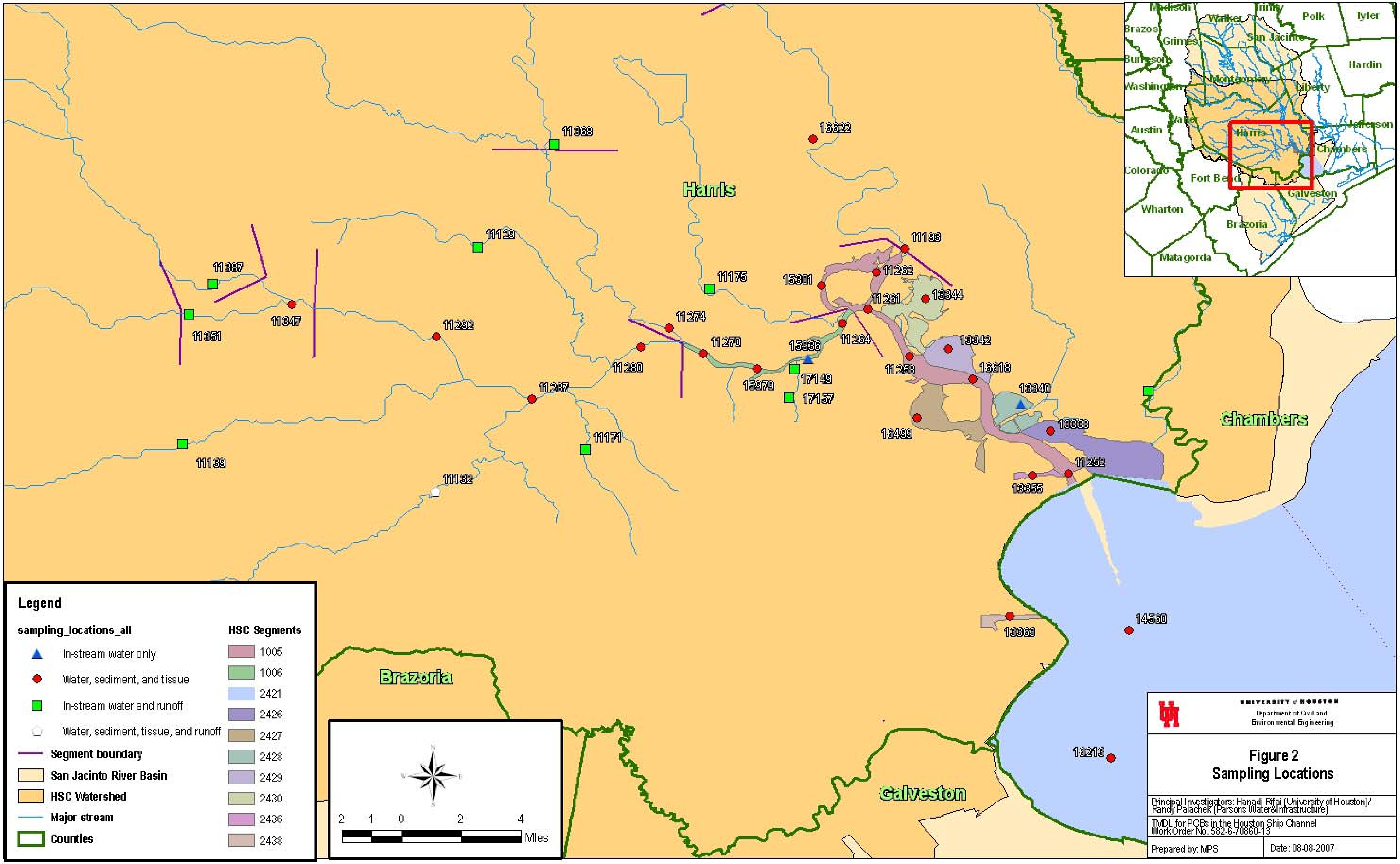


Figure 2
Sampling Locations

Principal Investigators: Hanadi Rifai (University of Houston)/ Randy Palachek (Parsons Water&Infrastructure)
TMDL for PCBs in the Houston Ship Channel
Work Order No. 582-6-70860-13
Prepared by: MPS
Date: 08-08-2007

APPENDIX C
FIELD DATA REPORTING FORM

FIELD DATA REPORTING FORM

Total Maximum Daily Load for PCBs in the Houston Ship Channel

TCEQ Work Order No. 582-6-70860-xx

Samplers:

Date	**Time**	**Station ID**	**Sample ID**	**Sampler flow rate (L/min)**	**Depth** [m]	**pH** [pH units]	**Temp.** [°Celsius]	**Specific Conduct.** [µS/cm]	**Salinity** [ppt]	**Flow Severity**[1]	**Observations**[2]

[1] 1-no flow, 2-low, 3-normal, 4-flood, 5-high, 6-dry

[2] Water appearance, weather, biological activity, unusual odors, other information (specific sample information, missing parameters, days since last significant rainfall)

TISSUE SPECIMEN INFORMATION FORM

STATION ID							M	M	D	D	Y	Y	Y	Y				REGION	

5-DIGIT, TEXAS SPECIES CODE	NUMBER OF INDIVIDUALS

74990		EPA Species Code
74995	87	Anatomy Part (59=whole, 87=edible)
81615		Number of species in tissue sample
00024		Length in inches (if one fish)
00023		Weight in pounds (if one fish)
84100		1=male; 2=femal2; 3=mixed; 4=unknown
72205		Median sampled species length (inches)
72203		Minimum sampled species length (inches)
72204		Maximum sampled species length (inches)
72202		Median sampled species weight (grams)
72200		Minimum sampled species weight (grams)
72201		Maximum sampled species weight (grams)

Collector ________________________________

APPENDIX D
CHAIN-OF-CUSTODY FORM

CHAIN OF CUSTODY RECORD

University of Houston
Dept. of Civil & Environmental Engineering
4800 Calhoun Road
Houston, Texas 77204-4003
(713) 743-6515

PARSONS
8000 Centre Park Drive, Suite 200
Austin, Texas 78754
(512) 719-6000

Laboratory Name
Laboratory Address
Laboratory Phone Number

PROJECT NAME/LOCATION
TMDL for PCBs in the Houston Ship Channel

CARRIER
☐ Federal Express
Other ____________________

PROJECT NUMBER

AIRBILL OR CARRIER ID#

SAMPLER(S):

(Signature)

							PRESERVATIVE ANALYSIS REQUIRED										
Date	Time	Sample ID/Desc.	Sample Type	Matrix	Sample Depth	NUMBER OF CONTAINERS	PCB congeners	TSS	TOC	TPH							REMARKS

Relinquished by: Date Time *(Signature)*	Relinquished by: Date Time	Relinquished by: Date Time *(Signature)*
Received by: Date Time *(Signature)*	Received by: Date Time	Received by: Date Time *(Signature)*

APPENDIX E
DATA MANAGEMENT PLAN

APPENDIX E. DATA MANAGEMENT PLAN

Data Management Process

Field measurements and sample data collection for water and tissue are performed according to the SWQM Procedures Manual (GI-252).

Personnel

Curt Burdorf is responsible for ensuring that the water and sediment sampling activities are conducted according to this QAPP. He will ensure that field data sheets are transmitted to the project data loader and the samples and COC forms are sent to the laboratories.

The Maxxam Analytics/ Xenco Laboratories Project Representatives are responsible for ensuring that the data resulting from laboratory analyses for this project are managed according to the lab QMPs and this QAPP. They will send laboratory results in electronic and hard copy to the University of Houston.

Nathan Howell, the project data manager, is responsible for entering the information on the field data sheets into an electronic system. He will also incorporate analytical data from the labs into the database. He is also responsible for reviewing the quality data from the UH/ParsonsTeam and the laboratories and performing all quality control checks on the data (Data validation checklist). Once data have been validated, he will be responsible for converting the data to the required format, archiving the data, backing up the data, and transferring the data to the University of Houston Project Manager for approval. Once approval from the project manager is received, the data manager will sent final QA-evaluated field data and sample analysis results in approved electronic format to Larry Koenig of the TCEQ.

Hanadi Rifai is responsible for managing the project for the University of Houston. She is responsible for ensuring that data is managed by the University of Houston and its subcontractors according to this data management plan and QAPP.

Larry Koenig is responsible for managing this project for the TCEQ. He will be responsible for receiving the water and sediment data and database review checklist from Nathan Howell of the Unoversity of Houston, reviewing the database review checklist for completeness, and conveying the data in the required format to Information Resources (IR) to be loaded into the SWQMIS database.

Systems Design – Data will be entered into, stored in, and transmitted between personal computers operating on Microsoft Windows XP, and using common commercially-available software. QuattroPro 6.01, Microsoft Access 2000, or Corel Paradox 8 will be used as databases, and data files created by these software programs will be transmitted between computers via e-mail. The TCEQ database hardware and software are described elsewhere and available from the TCEQ Data Manager.

Data Dictionary

Terminology and field descriptions for data to be entered into the SWQMIS database are included in the *SWQM Data Management Reference Guide*, 2007. For the purposes of verifying which codes are included in this QAPP, a table outlining the codes that will be used when submitting data under this QAPP is included below.

Name of Monitoring Entity	Tag ID/ prefix	Submitting Entity	Collecting Entity	Monitoring Type
University of Houston	UH	UH	UH	RT/BF[a]
Parsons	PE	UH	PE	RT/BF[a]

[a] **RT** will be used for ambient data usable for 305b/303d assessments (i.e., in-stream water and sediment), while **BF** will be used for non-ambient data not to be used for 305b/303d assessments (i.e., runoff and effluent).

Parameter codes for data collected under this project are included in Tables A.1 and A.2 of section A7.

Data Management Plan Implementation –

Field Observations

Instantaneous field observations will be recorded on the appropriate field data reporting forms (Appendix C). These forms will be reviewed for accuracy and copied by the person(s) performing the sampling, then provided to the University of Houston project manager along with a copy of the sample COC form, who will review them for accuracy and completeness. Following his review, the UH Project Manager will provide the forms to the UH data manager, who will enter the data in an electronic database created in Microsoft Access 2000 software. The project database will be maintained on a UH computer that is backed up weekly. The data manager will then store hard copies of data forms in the project files in the University of Houston field office.

Data will be verified via the procedures described in Section D2 (Verification and Validation Methods). The data to be verified (listed by task in Table D.1) are evaluated against project specifications (Section A7) and are checked for errors, especially errors in transcription, calculations, and data input. Potential outliers are identified by examination for unreasonable data, or identified using computer-based statistical software.

Original data recorded on paper files are stored for at least five years in a locked, restricted access area in the UH field office.

Flow of data: Field Sampling Personnel → UH Project Manager → UH Data Manager → electronic database → Project QAO → UH Data Manager → TCEQ.

Laboratory Measurements

Sample analysis data are recorded by the laboratory analyst and maintained on the laboratory information management system (LIMS) on the laboratory's server. Sample results will be transferred to the University of Houston Project Manager in Microsoft Excel spreadsheet format via e-mail. The University of Houston Project Manager will check the data file for accuracy and completeness, then forward the data file to the project data manager for import into the project Microsoft Access database. Data will be verified via the procedures described in Section D2 (Verification and Validation Methods).

Flow of data: Laboratory Analyst → LIMS → Laboratory Manager → UH Project Manager → UH Data Manager → Project QAO → UH Data Manager → TCEQ.

Data will be transferred electronically to TCEQ in pipe-delimited ASCII text through email as attachments.

Quality Assurance/Control - See Section D of this QAPP.

Migration/Transfer/Conversion - When the data verification and validation is complete, Nathan Howell, the Project Data Manager, will convert the Microsoft Access database into the appropriate TCEQ-approved format (see Data Dictionary) The data files will be provided in ASCII text with each field delimited by the pipe character (|) in the field format detailed below. The Project Data Manager will transfer these electronic files to the TCEQ Project Manager by email, followed up by a backup hard copy on CD-ROM media through the U.S. Postal Service. After approving the database review checklist, the TCEQ Project Manager will convey the file to the TCEQ Data Manager. The TCEQ Data Manager will run the TCEQ automated screening procedure on the file to check for errors and outliers, then forward the results to the TCEQ Project Manager. Upon approval of the TCEQ Project Manager, the TCEQ Data Manager will add this data to the SWQMIS database.

Backup/Disaster Recovery – Data files stored on the network servers at the University of Houston, Parsons, and TCEQ computer systems are routinely backed up. After a summary report is produced at the University of Houston, it will then be saved to a CD-ROM for distribution and archive at the UH field office. Copies of the field data reporting forms and laboratory paper records will be maintained, at the University of Houston and laboratories, respectively, for a period of five years as additional insurance against data loss.

Archives/Data Retention - Complete original data sets are archived on permanent media (USB disk or CD-ROM) and retained on-site by the University of Houston for a retention period specified in Table A9.1 Project Documents and Records.

Information Dissemination - Project updates will be provided to the TMDL Project Manager in progress reports and the information will be made available at stakeholder meetings. Environmental data collected as part of the project described in this QAPP will be accessible to the general public from the SWQMIS database once the data has undergone the QA/QC protocol described herein.

APPENDIX F
DATA REVIEW CHECKLIST

TCEQ TMDL PROGRAM
DATA REVIEW CHECKLIST

QAPP Title: ____

Effective Date of QAPP:________________________

Y, N, or N/A

Data Format and Structure

A. Are there any duplicate *Tag ID* numbers? ______
B. Are the *Tag prefixes* correct? ______
C. Are all *Tag ID* numbers 7 characters? ______
D. Are TCEQ station location (SLOC) numbers assigned? ______
E. Are sampling *Dates* in the correct format, MM/DD/YYYY? ______
F. Is the sampling *Time* based on the 24-hour clock (e.g. 13:04)? ______
G. Is the *Comment* field filled in where appropriate (e.g. unusual occurrence, sampling problems, unrepresentative of ambient water quality) and any punctuation deleted? ______
H. *Submitting Entity, Collecting Entity and Monitoring Type are valid and used correctly?* ______
I. Is the sampling date in the *Results* file the same as the one in the *Events* file? ______
J. Values represented by a valid parameter code with the correct units? ______
K. Are there any duplicate parameter codes for the same *Tag Id*? ______
L. Are there any invalid symbols in the Greater Than/Less Than (*GT/LT*) field? ______
M. Are there any tag numbers in the *Results* file that are not in the *Events* file? ______
N. Have confirmed outliers been identified? (with a ■1" in the Verify_flg field) ______
O. Have grab data (bacteria, for example) taken during 24-hr events been reported separately as RT samples? ______
P. Is the file in the correct format (ASCII pipe-delimited text)? ______

Data Quality Review

A. Are all the values reported at or below the AWRL? If no, explain on next page. ______
B. Have the outliers been verified? ______
C. Checks on correctness of analysis or data reasonableness performed? ______
e.g.: Is ortho-phosphorus less than total phosphorus?
Are dissolved metal concentrations less than or equal to total metals?
D. Have at least 10% of the data in the data set been reviewed against the field and laboratory data sheets?_ ______
E. Are all parameter codes in the data set listed in the QAPP? ______
F. Are all stations in the data set listed in the QAPP? ______

Documentation Review

A. Are blank results acceptable as specified in the QAPP? ______
B. Were control charts used to determine the acceptability of field duplicates? ______
C. Was documentation of any unusual occurrences that may affect water quality included in the Event file Comments field? ______
D. Were there any failures in sampling methods and/or deviations from sample design requirements that resulted in unreportable data? If yes, explain on next page. ______
E. Were there any failures in field and laboratory measurement systems that were not resolvable and resulted in unreportable data? If yes, explain on next page. ______

Describe any data reporting inconsistencies with AWRL specifications. Explain failures in sampling methods and field and laboratory measurement systems that resulted in data that could not be reported to the TCEQ. (attach another page if necessary):

____
____
____
____
____
____
____
____

Date Submitted to TCEQ: ________________________________
Tag ID Series: ____
Date Range: ____
Data Source: ____
Comments (attach README.TXT file if applicable):

____
____
____
____

University of Houston Data Manager: ____Date: __________

Data was collected as specified in the QAPP? Yes No (based on the responses above)

> Did the contractor describe any data reporting inconsistencies with the AWRL specifications? Yes No
> If yes, ensure the data was not reported to the TCEQ.
>
> Did the contractor list any failures in sampling methods, field measurements, and/or laboratory measurements?
> Yes No
> If yes, ensure the data was not reported to the TCEQ.

TMDL Project Manager:____Date:___________

APPENDIX G
EXAMPLE LETTER

APPENDIX G. EXAMPLE LETTER TO DOCUMENT ADHERENCE TO THE QAPP

TO: *(name)*
(organization)

FROM: Hanadi Rifai
University of Houston

Please sign and return this form by (*date*) to:

4800 Calhoun Rd.
Houston, TX 77204-4003

I acknowledge receipt of the referenced document(s). I understand the document(s) describe quality assurance, quality control, and other technical activities that must be implemented to ensure the results of work performed will satisfy stated performance criteria.

Signature Date

ATTACHMENT 1

STANDARD OPERATING PROCEDURES (SOPS) FOR WATER SAMPLING

STANDARD OPERATING PROCEDURES (SOPs) FOR WATER SAMPLING

Prior to going out in field

1. PREP AT FIELD OFFICE: Meet teammate(s) at previously arranged time. Go through checklist to ensure you have everything needed.

Field Checklist

Infiltrex 300 High Volume Water Sampler (Axys)
YSI probe
Sampler manuals
3000 watt generator
4 Glass fiber filters (1 µm)
140-µm pre-filters
XAD2 resin columns (2 if collecting QC samples, 1 otherwise)
Teflon tubing for sampling unit(s)
Stainless steel fittings
Coolers and ice
Heavy-duty aluminum foil
Sealable plastic bags (1 quart and 1 gallon sizes)
Trash bags
Plastic sample containers with lids
Alconox
Powder-free latex gloves
Rubber gloves
Protective glasses
Hearing protection
Scrub brush
Deionized water
Tongs
Forceps
Labels
Wrenches and tool box
Sharpie markers
Logbook
Sample containers (Xenco bottles)
45-µm syringe filters
Syringes
Sulfuric acid
pH paper
Calibration solutions for YSI probe

2. IDENTIFY SITE AND QUALITY CONTROL SAMPLES: The site that you will be sampling is identified in the schedule posted on the field office along with any quality control samples you need to take.

   Quality control (QC) samples will be taken throughout the sampling. Ensure that enough bottles and sampling containers have been taken to collect the QC samples prior to leaving the field office. There are four types of quality control samples that will be taken in the field:

   - **Duplicates**: Field duplicates will be taken as noted on the Site ID List. Duplicate samples will involve collecting 2 different samples at one location. Duplicates will be labeled with "Dup" in addition to the sample ID. Duplicates should be collected for PCBs and TSS at a rate of one per 20 samples.

   - **Equipment blanks:** Equipment blanks will be taken once every 20 samples. Equipment blanks involve taking 1 liter of DI water and running it through a previously decontaminated high-volume unit. The XAD-column and filter are then removed and labeled "Equipment Blank."

   - **Field blanks:** Field blanks will be taken once every 20 samples. Field blanks identify any contamination that results from simply transporting and handling the glass fiber filters in the field. A clean filter is carried to the field, labeled as "Field Blank" and packed in the cooler with the samples collected during the day. The field blanks are never connected or inserted in the sampling unit. No field blanks are necessary for the resin column.

   - **Recovery columns:** Recovery columns quantify the amount of target analytes in the sample water that passes completely through the first column without binding to the XAD resin. Recovery columns are collected by connecting two columns to the sampling unit in series, and filtering 100-400 liters of water as described in the sampling procedures. The recovery column is handled in the same manner as a typical sample column; however, it is packaged separate from the sample column. When recovery columns are collected, please label them with the site ID and add #1 and #2 for the sample and recovery column, respectively.

In the Field

1. ARRIVAL AT SITE: Upon arrival at site, check site description in the list of sampling sites to make sure you are at the right location. Record date, station ID and lat-long coordinates in the field logbook

2. HIGH-VOLUME SAMPLING

2.1 Initial Setup

Prior to sampling, a clean 140 μm inline filter is placed on the intake port of the Infiltrex sampling unit. The Teflon intake line is then connected to the intake structure at an initial depth of 1 ft. The outlet tubing is connected to a floating outlet > 10 feet from the boat, on the opposite end of the boat from the intake tubing. The boat is anchored from the bow and the intake is 10 feet off the port bow. The outlet is 10 feet off the stern, which keeps a distance of > 30 feet, as well as wind action and/or forward motion, from causing mixing of the water with effluent. Connect the outlet line to the outlet port and position line such that it drains outside of the boat. The sampling unit can then be plugged into the generator for power.

2.2 Sampling Procedures

Step 1 - Run ambient water through the system for about 5 minutes (do not connect the inlet to the flow meter).

Step 2 – Insert Glass Fiber Filter

- Remove one filter housing from unit.
- Insert glass fiber filter into filter housing touching only the plastic wrapper. Do not directly touch any exposed surfaces of the filter. If the exposed filter comes in contact with anything other than the interior of the filter housing, the filter is discarded, and a new filter is used.
- Once the filter is in place, reconnect the filter housing to sampling unit.

Step 3 – Connect XAD Resin Column

- Remove nut from spiked end of column, and place nut back in sealable plastic bag that the column was sent in from the lab.
- Connect the post-filter line to the spiked end of the resin column.
- Remove the nut from the other end of the column, and place nut in the plastic bag. The plastic bag is placed in the labeled column sample container, which in turn is placed in a clean cooler.
- Connect the open end of the column to the post-column line.
- The post-column line is then attached to the Infiltrex sampling unit just before the volume totalizer unit.

Step 4 – Record relevant information in logbook

- Initial Volume in Meter
- Unit IDs (identifying which one was used for sample and dups)
- XAD Resin Column IDs and Filter batch numbers (check it is a 1 micron filter)

Step 5 – Check Control Unit Settings

- Check the control unit to make sure the RPM light is on. If light is not on, press <STOP/RESET>.
- Make sure the FORWARD direction light is on. If the REVERSE light is on, press the <FORWARD/REVERSE> button.
- Make sure the PROGRAM light is NOT on. The pump will not operate in PROGRAM mode. If the PROGRAM light is on, press the <STOP/RESET> button.
- Use the UP and DOWN arrows to control the RPMs. A good initial starting point is 1200 RPMs.

Step 6 – Begin Pumping

- Press <ON> to begin pumping. It may be necessary to increase the RPMs to get the pump started. It takes a few moments to get water flowing through the entire system.
- The moment that water is seen in the post-column line, reset the volume totalizer to 0.0. This is necessary to get an accurate volume measurement, because the totalizer will measure the water that was already in the lines from the cleaning process even though this water did not pass through the filter and resin column.
- Adjust the RPMs until the flowmeter indicates that the unit is operating at the target pumping rate of **1.5** liters / minute.
- Check all fittings to make sure there are no leaks.
- Note on the field data sheet the start time, pumping rate, and initial pressure on the system.

Step 7 – Change pumping depth

- Every 30 minutes, stop the pump and adjust the depth of the intake to alternate among surface (1 ft deep), middle depth (to be determined according to total depth at the site), and deep (2 ft above bentic layer).
- Once the depth is adjusted, re-start the pump and record time and depth in the log book.

Step 8 – Check System

- Check the sampling unit periodically (at least every hour) to ensure unit is operating correctly. Check and record the volume filtered and flow rate both from flow meter and from measurement using calibrated cylinder. Record pressure, if available.
- If the pressure reaches 20 p.s.i, the glass fiber filter must be changed.
- If the flow rate has decreased, increase the RPMs to maintain the optimum pumping rate of 1.5 liters / minute. If increasing the RPMs does not help, either the glass fiber filter or the inline filter must be changed.

Step 9 – Completion of Sample Collection

- The sampling unit is operated continuously until the desired volume of water has been filtered.
- Once desired volume has been filtered, cease pumping by pressing <STOP> on the control unit.
- Record stop time and volume filtered on the logbook.

- Turn main switch on unit to off.

2.2.1 Changing the Glass Fiber Filter

The glass fiber filter must be changed if the pressure reaches 20 p.s.i., or if adjusting the RPMs does not increase the flow rate.

- Insert a glass fiber filter in the unused filter housing as described in Step 1.
- Press <STOP/RESET> to temporarily cease pumping.
- Record the stop time and volume filtered.
- Switch both directional flow valves to point in the direction of the filter housing containing the clean filter.
- Press <START> to resume pumping. See Sample Handling Procedures to remove the used filter from the filter housing.

2.2.2 Changing the Inline Filter

The inline filter should be changed when the optimum flow rate (1.5 L/min) cannot be maintained by adjusting the RPM.

- Press <STOP/RESET> to temporarily cease pumping.
- Switch both directional flow valves to point in the direction of the filter housing containing the clean inline filter element.
- Press <START> to resume pumping.
- Record time and volume filtered on field data sheet.
- Disconnect the used inline filter, and replace with a clean filter element and housing. See Section 3.4.1 for decontamination procedures for inline filters.

2.3 Sample Handling Procedures

The following procedures describe how the used filters and XAD resin columns must be handled once sampling is complete.

2.3.1 Glass Fiber Filters

- On a clean, flat surface, place two pieces of heavy-duty aluminum foil large enough to wrap the filters in.
- Remove the housing unit while being careful not to jostle the filter inside.
- While holding the filter housing over the foil, use clean tongs to remove the used filter from the housing.
- Wrap the filter in both pieces of foil.
- **Label the filter with date, sample id number**, **and requested analysis**.
- Place wrapped filter in a sealable plastic bag.
- Put the plastic bag on ice in a cooler.
- Discard water in filter housing, and rinse housing with DI water.

- Reconnect filter housing to sampling unit.

2.3.2 XAD Resin Columns

- Unscrew the column from the post-filter line, and replace the end cap.
- Unscrew the column from the post-column line, and replace the end cap.
- Place the column in a sealable plastic bag, and **label the bag with date, sample ID number, and requested analysis**.
- Put the sample immediately on ice in a cooler.

2.4 Decontamination Procedures

Before the collection of samples, the sampler should be completely cleaned and tested for leaks and other mechanical problems. The sampler is cleaned chemically after every sampling day. Clean latex gloves should be worn during equipment decontamination. Once equipment has been cleaned, care should be taken to avoid touching or otherwise contaminating any surfaces that will come in contact with the sample water (e.g. inside surface of filter housings).

Step 1 – Clean Filter Housings and O-rings

- Remove filter housings from unit
- Wash housings and o-rings using a scrub brush and lab grade detergent.
- Rinse housings and o-rings with deionized water. Use cleaned forceps to hold o-rings while rinsing.
- Allow cleaned items to air dry.
- Place o-rings in filter housings, and reconnect housings to sampling unit.

Step 2 – Clean Pre-filter (see section 2.4.1).

Step 3 – Flush Sampling Unit

- Plug unit in (generator or wall outlet) and power up the sampling unit using the main toggle switch.
- Check that the flow control valves on top of the unit both point in the same direction. The arrow on the valve handles point to the filter housing that water will be drawn through.
- Flush the unit with 1 gal of DI water (do not recycle it)
- With the intake line submerged in water with lab grade detergent, press the <ON> button on the control panel to start the pump.
- Increase the RPMs of the pump until the pump is primed, and water is flowing through the unit.
- Draw soapy water through the system for 10 minutes (recycling),
- Empty filter holder and reconnect
- Run 5 liters of deionized water until soap has been flushed out of the system.
- Empty filter holder and reconnect

- Next, disconnect the post-column line where it reenters the pump housing and position the line such that it drains to a waste container. **This prevents solvents from passing through the volume totalizer.**
- Place the ends of the intake and outlet lines in a wash bottle with approximately 500 mL of acetone. Pass the solvent through the unit for about 5 minutes.
- **Empty filter holder in a waste container labeled "acetone waste" and reconnect.**
- Following the acetone rinse, place the end of the intake line in a wash bottle with 1 gallon of deionized water. Continue pumping until all of the water has been drawn through the tubing. Collect the first liter of water in a container labeled "acetone-water waste," the remaining water can be collected in a regular waste container and dumped in the sink.
- Empty filter holder and place it on top of the unit to allow it to dry overnight

2.4.1 Inline Filter Decontamination

- The inline filter must be cleaned prior to use.
- Unscrew the top portion of the inline from the filter housing.
- Remove the inner filter element from the housing.
- Place filter element and housing in warm detergent water, and use a small brush to remove dirt particles.
- If filter element is still clogged or has become misshapen, the filter element should be replaced.
- Once all particles are removed, the inline filter is reassembled.
- Using a wash bottle, squirt a small amount of acetone through the inline filter. Once dry, the filter is ready to use. Keep all cleaned inline filters that are not in use in sealable plastic bags.

2.4.2 Decontamination of Tongs and Forceps

- Prior to use, the tongs and forceps must be cleaned.
- Use a scrub brush with lab grade detergent to thoroughly clean the tongs and forceps.
- Rinse with deionized water, then with a small amount of acetone.
- After cleaning, store the tongs and forceps in a clean storage container until needed. Once used, the utensils should be placed in a separate container used only for contaminated items that need to be cleaned before use.

3. YSI READINGS: Readings should be taken at 3-5 depths twice during the day (beginning and end of sampling event). Record readings in the Field Log Book.

4. COLLECT SAMPLES FOR TSS: Clean a big Erlenmeyer flask using DI water several times. Every 30 minutes grab 250 mL of ambient water using a calibrated cylinder. Pour the sample in the Erlenmeyer flask, cap it and place in the ice chest. Write time of collection in the field logbook. The composite sample should be on ice and in the dark during the whole day so be careful no to leave the ice chest open. At the end of the day mix the contents of the Erlenmeyer flask thoroughly and pour the samples in the sample

containers. Pour 500 mL directly into a new, pre-cleaned bottle and place the labeled container in the ice chest.

After Field Sampling

1. RETURN TO FIELD OFFICE: Bring ***ALL*** equipment back into the office. Unpack the samples and place in a refrigerator in the office.

2. REPACK SAMPLING BOXES: Replenish any supplies that have been used (except the XAD-column that should be grabbed in the morning prior to leaving the field office). Using the checklist, mark everything that has either been replenished or has an adequate supply. Note any problems or missing items on the checklist.

3. COPY LOGBOOK: Make a copy of all the pages used during the day.

4. CLEAN SAMPLER: Decontaminate the high-volume sampler using the procedure described previously.

APPENDIX F - DRAFT MODELING QAPP

Total Maximum Daily Loads of PCBs in the Houston Ship Channel Quality Assurance Project Plan for Modeling

Revision 0

Type of Model(s): Water Quality Analysis Simulation Program (WASP)

Segment(s): 1007, 1006, 1005, 0901, 2421, 2426, 2427, 2428, 2429, 2430, 2436, 2438

Date submitted to TCEQ: 08/15/2007

Grant Title: 319 05-06 NPS
Federal Grant ID: C9-996146-11

The University of Houston

Hanadi Rifai
Associate Professor
Dept. of Civil & Environmental Engineering
University of Houston
N107 Engineering Building 1
Houston, TX 77204
(713)743-4271
Rifai@uh.edu

Total Maximum Daily Load Program
Chief Engineer's Office, Water Programs

Texas Commission on Environmental Quality
P.O. Box 13087, MC - 203
Austin, Texas 78711-3087

This QAPP is effective for a period of one year from approval date.

Questions concerning this QAPP should be directed to Hanadi Rifai.

SECTION A: PROJECT MANAGEMENT

A2 APPROVAL PAGE

Texas Commission on Environmental Quality
Chief Engineer's Office, Water Programs

Faith Hambleton, Program Manager Date
Total Maximum Daily Load Program

Anju Chalise, Grant Manager Date
319 05-06 NPS

Larry Koenig, Project Manager Date
Total Maximum Daily Load Program

Office of Compliance and Enforcement
Compliance Support Division

Stephen Stubbs, Manager Date
Quality Assurance Program

Kyle Girten, Quality Assurance Specialist Date
Quality Assurance Program

Signatures below indicates commitment to follow the procedures in this QAPP:

Hanadi Rifai, Project Manager Date
University of Houston

Nathan Howell, Quality Assurance Officer Date
University of Houston

Note: The UH Quality Assurance Officer will secure written documentation (such as the letter in Appendix A) from each sub-tier project participant (e.g., subcontractors, other units of government) stating the organization's awareness of and commitment to requirements contained in this quality assurance project plan and any amendments or revisions of this plan. The UH Quality Assurance Officer will maintain the documentation as part of the project's quality assurance records, and will ensure that the document is available for review. **Copies of this documentation will also be submitted as deliverables to the TMDL Project Manager within 30 days of final TCEQ approval of the QAPP.**

U.S. Environmental Protection Agency, Region 6

Donna Miller, Chief Date
State/Tribal Programs Section

Assistance Programs Branch

____

Randall Rush, Project Officer Date
Assistance Programs Branch

A3 DISTRIBUTION LIST

List the individuals and their organizations who need copies of the approved QA Project Plan and any subsequent revisions, including all persons responsible for implementation (e.g., project managers), the QA Managers, and representatives of all groups involved. Paper copies need not be provided to non-TCEQ individuals if equivalent electronic information systems can be used.

Texas Commission on Environmental Quality
P.O. Box 13087
Austin, Texas 78711-3087

Chief Engineer's Office
Water Programs
Larry Koenig, TMDL Project Manager
MC-203
(512) 239-4533

Office of Compliance and Enforcement
Compliance Support Division
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A3-1 List of Acronyms

CAR	Corrective Action Report
DO	Dissolved Oxygen
EPA	Environmental Protection Agency
QA	Quality Assurance
QA/QC	Quality Assurance/Quality Control
QAO	Quality Assurance Officer
QAM	Quality Assurance Manual (or Manager)
QAPP	Quality Assurance Project Plan
QAS	Quality Assurance Specialist
QMP	Quality Management Plan
RE	Relative Error
SOP	Standard Operating Procedure
TMDL	Total Maximum Daily Load
TCEQ	Texas Commission on Environmental Quality
USEPA	United States Environmental Protection Agency

A4 PROJECT/TASK ORGANIZATION

U.S. EPA Region 6

Randall Rush
EPA Project Officer
Responsible for managing the project for EPA. Reviews project progress and reviews and approves QAPP and QAPP amendments.

TCEQ Chief Engineer's Office
Water Programs

Faith Hambleton
TMDL Program Manager
Responsible for managing the TCEQ TMDL Program. Supervises the TMDL staff. Oversees the development of QA guidance for the TMDL Team to ensure it is within pertinent frameworks of the TCEQ. Reviews and/or approves all TMDL Projects, QA audits, QAPPs, agency QMPs, corrective action reports, work plans, and contracts. Enforces corrective action where QA protocols are not met. Ensures TCEQ TMDL personnel are fully trained and TMDL projects are adequately staffed.

Larry Koenig
TMDL Project Manager
Responsible for ensuring that the project delivers products of known quality, quantity, and type on schedule to achieve project objectives. Provides the primary point of contact between the UH and the TCEQ. Tracks and reviews deliverables to ensure that tasks in the work plan are completed as specified in the contract. Reviews and approves QAPP and any amendments or revisions and ensures distribution of approved/revised QAPPs to TCEQ participants.

Responsible for verifying that the QAPP is followed by the UH. Notifies the TCEQ QAS, TMDL QAS, and the Program Manager of significant project nonconformances, CARs, and corrective actions taken as documented in quarterly progress reports from UH Project Manager.

TCEQ Compliance Support Division

Kyle Girten
TMDL Quality Assurance Specialist
Assists the TCEQ TMDL Project Manager and the TMDL QAS on QA-related issues. Coordinates reviews and approves QAPPs and amendments or revisions. Conveys QA problems to appropriate TCEQ management. Monitors implementation of corrective actions. Coordinates and conducts audits.

University of Houston (UH)

Hanadi Rifai

University of Houston Project Manager

The UH Project Manager is responsible for ensuring that tasks and other requirements in the contract are executed on time and with the quality assurance/quality control requirements in the system as defined by the contract and in the project QAPP; assessing the quality of subcontractor/participant work; submitting accurate and timely deliverables to the TCEQ TMDL Project Manager; and coordinating attendance at conference calls, training, meetings, and related project activities with the TCEQ. Verifies that the data and model outputs meet the data quality objectives of the project and are suitable for reporting to TCEQ. Responsible for verifying that the QAPP is distributed and followed by the UH (including all subcontractors) and that the project is producing products of known and acceptable quality. Responsible for ensuring adequate training and supervision of all activities involved in the project, including the facilitation of audits and the implementation, documentation, verification and reporting of corrective actions. Ensures modeling work satisfies project objectives and contract and workplan requirements.

Nathan Howell

University of Houston Quality Assurance Officer

Responsible for coordinating development and implementation of the UH's QA program. Responsible for writing and maintaining the QAPP and monitoring its implementation. Responsible for maintaining records of QAPP distribution, including appendices and amendments. Ensures the data acquired for the project is of known and acceptable quality and adheres to the specifications of the QAPP. Assists Project Manager and modeling staff in verifying that the data and model outputs meet the data quality objectives of the project and are suitable for reporting to TCEQ. Responsible for maintaining written records of sub-tier commitment to requirements specified in this QAPP. Also responsible for maintaining records of QAPP distribution. Responsible for identifying, receiving, and maintaining project quality assurance records. Responsible for compiling and submitting any QA report (audit results, CARS, etc). Responsible for coordinating with the TCEQ QAS to resolve QA-related issues. Notifies the UH Project Manager and TCEQ Project Manager of particular circumstances which may adversely affect the quality of the products. Coordinates the research and review of technical QA material and data related to the model system design and analytical techniques. Conducts assessments of participating organizations during the life of the project as noted in Section C1. Implements or ensures implementation of corrective actions needed to resolve nonconformances noted during assessments.

Nathan Howell
University of Houston Data Manager
Responsible for the monitoring the acquisition, processing, transfer, and archiving of applicable data and/or model outputs (finished data). Oversees data management for the project. Responsible for ensuring that all model input and output data are properly reviewed and submitted in the format specified in the contract or by the TMDL Project Manager. Performs data quality reviews (data is of right type and quality, and format) prior to transfer of applicable data to TCEQ. Provides the point of contact for the TCEQ TMDL Project Manager to resolve issues related to the data and assumes responsibility for the correction of any data errors.

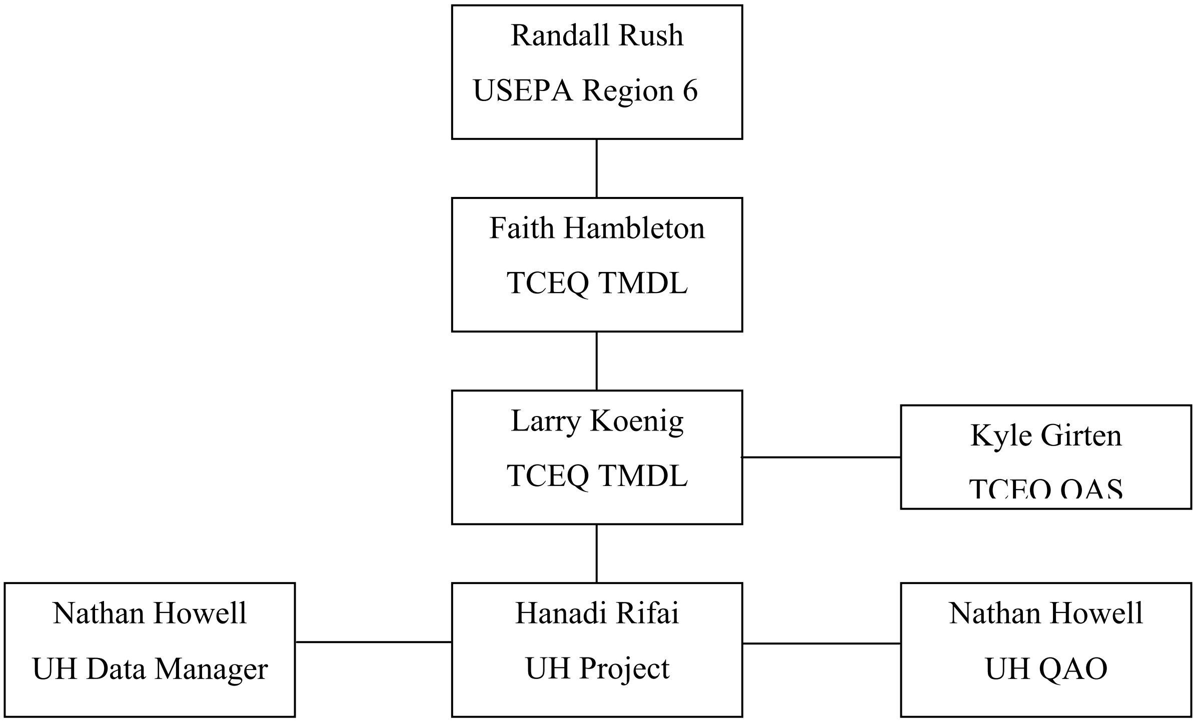

Figure A4.1 Organization Chart

A5 PROBLEM DEFINITION/BACKGROUND

A5-1 Purpose

The purpose of the QAPP is to clearly delineate the University of Houston's QA policy, management structure and procedures to implement the QA requirements necessary to verify, calibrate, and validate the output of the modeling process. This QAPP is reviewed by the TCEQ to help ensure that the outputs and data generated for the purposes described within are scientifically valid and legally defensible. This process will facilitate the use of project outputs and data by the TMDL program and other programs deemed appropriate by the TCEQ.

A5-2 PCBs in the Houston Ship Channel (HSC)

Polychlorinated biphenyls (PCBs) are widespread organic contaminants that are environmentally persistent and can be harmful to human health even at low concentrations. A major route of exposure for PCBs worldwide is through food consumption, and this route is especially significant in seafood. The discovery of PCBs in seafood tissue has led the Texas Department of State Health Services to issue seafood consumption advisories, and some of these advisories have been issued for the Houston Ship Channel (HSC). Two specific advisories have been issued for all finfish species based on concentrations of PCBs, organochlorine pesticides, and dioxins. ADV-20 was issued in October 2001 and includes the HSC upstream of the Lynchburg Ferry crossing and all contiguous waters, including the San Jacinto River Tidal below the U.S. Highway 90 bridge. ADV-28 was issued in January 2005 for Upper Galveston Bay (UGB) and the HSC and all contiguous waters north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. These two advisories represent a large surface water system for which TMDLs need to be developed and implemented.

PCB concentrations have been sampled in water, sediment, and tissue in the HSC as early as 1974 (in the case of sediment and water). Concentrations, initially in terms of Aroclors and later in terms of total PCBs, have been a concern since that time. Various industries have made or used PCBs along the HSC since before the 1970s, and the persistent nature of these PCBs means that sediments have served as a repository for the contaminant. PCBs can reenter the water column and are incorporated into fish, or the organisms that come in contact with sediment may take them in directly. Industrial production and use of PCBs has been banned in the US since 1977 (De Voogt and Brinkman, 1989), but contemporary sources to the HSC may still exist in the form of dry and wet air deposition, runoff from PCB disposal areas, illegal PCB disposal, or incidental PCB production in chemical wastewater streams. A focus of the sampling effort will be to determine the contributions of these various sources and transport mechanisms in order to correctly model the effects for better HSC understanding and decision-making. Where these contributions cannot be easily measured, assumptions will be made to model the effects.

A 2002-2003 PCB sampling effort in the Channel was conducted as part of the HSC dioxin TMDL. That study showed that "hot spot" regions exist in the HSC concentrated around the largest industrialized segments, segments 1006 and 1007 (Figure A5-1) It also pointed at the possibility of unique contemporary sources because unusual non-Aroclor PCB congener 209 was found. And finally sediment transport of PCBs seemed likely since some of the congener profiles in various tributaries and main channel segments were similar.

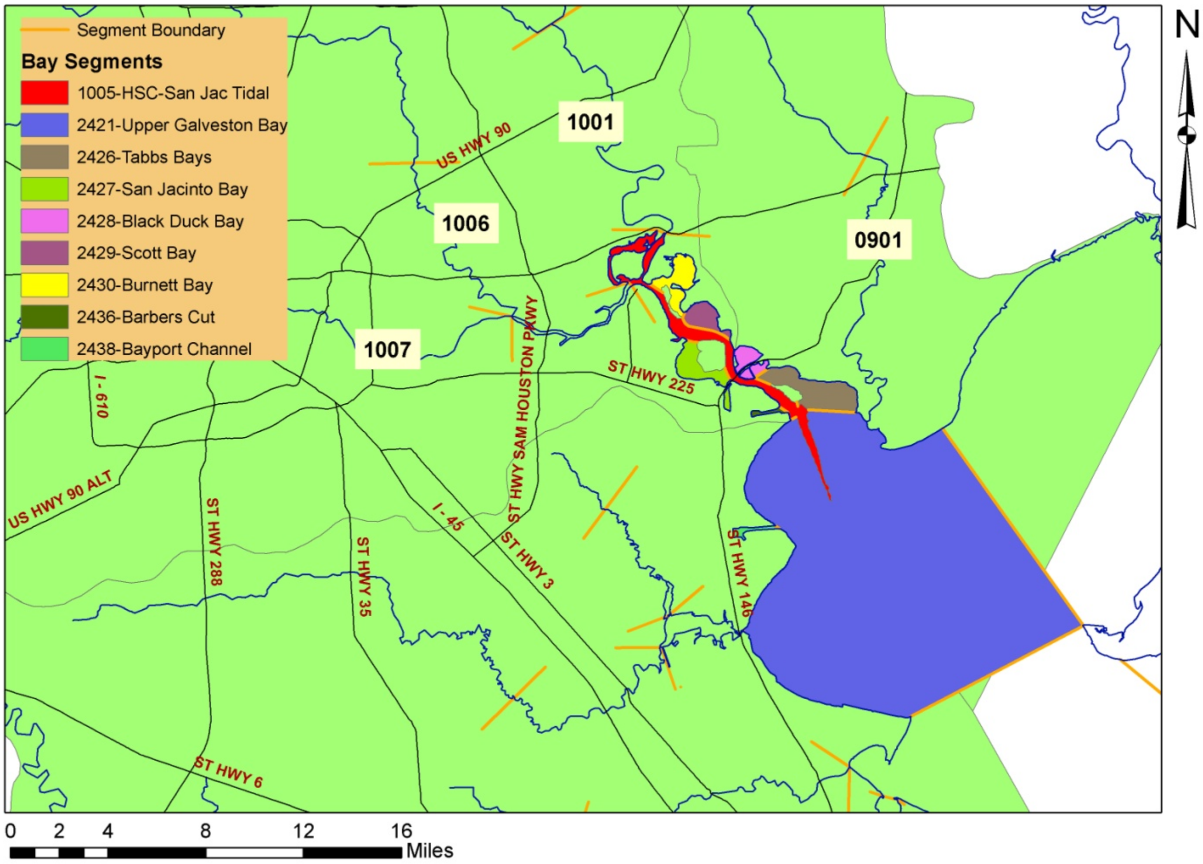

Figure A5-1. Houston Ship Channel Site Segmentation

The objectives of the TMDL modeling is to characterize the state of PCBs in the HSC, define the inputs to the HSC system, and understand the way that the HSC system would respond to changes put upon it either by natural or anthropogenic means. In order to do that, sampling will be conducted by the University of Houston to gather necessary model inputs into an RMA2-WASP7 (combination hydrodynamic-water quality) model similar to what was used in the dioxin TMDL. The model combined with a load allocation spreadsheet will allow scenarios to be run on a virtual HSC that can help decision-makers to attain water quality standards and safety in the HSC through the manipulation of loads into the HSC (e.g. regulating PCB releasing facilities, dredging sediment) or by altering components of the system (e.g. changing the way channel maintenance is done, restricting activities from certain parts of the channel) that affect transport within the HSC system.

A6 PROJECT TASK/DESCRIPTION AND SCHEDULE

Project tasks related to the determination of a PCB TMDL in the HSC include the following:

1. Task 1 - Develop a Water Quality Model of the HSC to Use in Connection with the Existing Hydrodynamic Model
    - Sub-Task 1.1 - Gather Non-Directly Measured Input Data
    - Sub-Task 1.2 - Gather and Organize New Monitoring Data
    - Sub-Task 1.3 - Modify Existing Setup of the Dioxin TMDL Water Quality Model
    - Sub-Task 1.4 - Develop Calibrated and Validated Water Quality Model using WASP7
    - Sub-Task 1.5 – Predictive Application of the Calibrated/Validated Model
2. Task 2 – Document Model Progress and Conclusions
    - Sub-Task 2.1 – Develop Draft Quarterly and Final Project Reports for the entire PCB TMDL Work Order
    - Sub-Task 2.2 – Prepare Revised Drafts of Quarterly and Final Project Reports for the entire PCB TMDL Work Order
    - Sub-Task 2.3 - Produce TCEQ Approved Quarterly and Final Project Reports for Task 1 Activities

A6-1 Project Task Descriptions

The previous task list is here further explained.

<u>Task 1 - Develop a Water Quality Model of the HSC to Use in Connection with the Existing Hydrodynamic Model.</u> The existing hydrodynamic HSC model is an RMA2 model that was used in the Dioxin TMDL Project. That TCEQ approved model will predict the hydrodynamics of the HSC system in order to generate hydrodynamic time series output in the form of flows and

water surface elevations. That data combined with other channel data (both data in existence and that which will be collected during the project) will be used to create a water quality model relevant to PCBs using the WASP7 simulation program. The model will be capable of simulating the spatial, temporal, and possibly vertical variability of the total PCBs in the HSC.

Sub-Task 1.1 – Gather Non-Directly Measured Input Data. There is a large set of data needs including channel geometry, tributary and upstream channel flow time series, previously collected PCB water and sediment concentrations, and other data sets mentioned in section 0 that need to be gathered, organized, and formatted for input into the WASP7 model. Part of this task will be to look at all of the model inputs required by WASP7 and checking those needs against the data that is available. The other large part of this task will be gain understanding about the RMA2 model output and the HSCREAD (Rifai, 2006) interface that loads it into WASP7. That output will need to be matched up correctly with the HSCREAD code in such a way to match the model grid that is needed to model PCBs as they are likely to be transported in the HSC.

Sub-Task 1.2 – Gather and Organize New Monitoring Data. New monitoring data will be gathered for many water quality parameters as well as fish and sediment concentrations beginning in the Fall of 2007. The data will be gathered according to the HSC PCB TMDL Monitoring Plan and the Monitoring QAPP. The data will need to be examined once it is received from the lab in order to ascertain the presence of outliers and to decide how best to divide the data into subsets for validation. It is anticipated that the previous monitoring data of 2002-2003 will serve as a calibration data set while the new data will be used for validation. In addition to dividing the new data for potential use in multiple validation sets, it will also need to be examined with the non-directly measured data gathered in Sub-Task 1.1 to determine the channel conditions during the time span of data collection. That is to say that the data needs to be assessed to provide data sets that focus on specific channel conditions of flow, rainfall patterns, and seasonality.

Sub-Task 1.3 - Modify Existing Setup of the Dioxin TMDL Water Quality Model. The current Dioxin TMDL Water Quality Model exists in WASP7. There are, however, the following fundamental differences in concept between modeling these two different constituents.

- Known PCB “hot spots” in the HSC are somewhat different than those found for dioxin
- Evidence exists that PCB transport may occur through model boundaries by way of sediment transport which was not the case for dioxin
- Point source loads may be more difficult to model for PCBs because current industrial sources of PCB are not as well understood
- A need for more vertical modeling of PCBs may be required since some vertical PCB monitoring will now be occurring as stated in the Monitoring Plan.

These differences and other differences that have not yet been determined means that at least initially the first difference between the two WASP7 models may be a change in the model grid layout. Furthermore, the physical coefficients that define contaminant behavior in WASP7 will be different. Though one might be able to look at such coefficient changes as a simple numbers changes, it is likely that these changes may make the running of the model completely different

Sub-Task 1.4 - Develop Calibrated and Validated Water Quality Model using WASP7. Once the model has been setup according to the best conceptualization of the channel and the physical-chemical properties of PCBs, then the model needs to be calibrated and verified. The calibration parameters for the model are explained in more detail in section 0, and they will be calibrated using data from the 2002-2003 PCB sampling set. Validation will happen through the data that will be collected in the Monitoring Plan.

Sub-Task 1.5 – Predictive Application of the Calibrated/Validated Model. The intended use of the completed model is to predict what will happen to water concentrations under varying load scenarios. Scenarios that could be run include elimination of point sources, elimination of non-point sources, removal of internal sediment loadings, etc. The model should give an accurate predictor of PCB levels under different loading scenarios so that an effective load reduction strategy can be formulated.

<u>Task 2 – Document Model Progress and Conclusions.</u> Model progress will be formally communicated to the TCEQ Project Manager by way of standard quarterly reports. Issues encountered in modeling and latest conclusions will be given. At some point, most of the modeling work will be complete. When that happens, most of the project will focus on dealing with the analysis of the model results and the various load scenarios that are needed. The completed modeling work will be documented in a quarterly report in a more final and conclusionary manner. The quarterly reports will continue to be generated for every year the project continues under each new work order. Each year will conclude with a summary final report, and the end of the project will have an all-encompassing project final report.

A6-2 Model Strategy

The dioxin TMDL project developed the hydrodynamic RMA2 model that was used for a three-year simulation for the years 2002-2005. The hydrodynamic output (water surface elevation, velocity, and flowrate) was used as input into the WASP7 water quality model. The fact that the dioxin TMDL has already been conducted helps to streamline the model development. The hydrodynamic model is non-specific to any particular contaminant describing only the behavior of the water in time. Contaminant fate and transport depends on these conditions as well as others. Thus, the RMA2 part of the model needs no specific further development work for the project. WASP7 is contaminant-specific, needing physical and chemical constants as well as calibration and verification datasets to make it predictive for PCBs. The general strategy then would be to apply the RMA2 model used in the dioxin TMDL to a different time span, and then to feed that output to a newly developed WASP7 module specific to PCBs. The RMA2 model might need some verification data applied to it since the time span is different, but it should be minimal. The WASP7 model might need a slightly different strategy in terms of water depth segmentation. The deeper parts of the HSC are slated to be measured at different depths. So it might be helpful in those places to have water layers divided into surficial and deep.

A6-3 Project Goal Completion

The model will serve the main project goal of achieving a PCB TMDL for the HSC by providing the TCEQ Project Manager with a reasonable approximation of likely channel behavior when various load reductions are attempted. The model will be presented to the TCEQ Project Manager in such a way that they can use it to understand the contaminant situation in the channel and make hypothetical changes in a realistic way.

A6-4 QAPP Revision

Until the work described is completed, this QAPP shall be revised as necessary and reissued annually on the anniversary date, or revised and reissued within 120 days of significant changes, whichever is sooner. The last approved versions of QAPPs shall remain in effect until revised versions have been fully approved; the revision must be submitted to the TCEQ for approval before the last approved version has expired. If the entire QAPP is current, valid, and accurately reflects the project goals and the organization's policy, the annual re-issuance may be done by a certification that the plan is current. This certification can be accomplished by submitting a cover letter stating the status of the QAPP and a copy of new, signed approval pages for the QAPP.

A6-5 QAPP Amendments

Amendments to the QAPP may be necessary to reflect changes in project organization, tasks, schedules, objectives and methods; address deficiencies and nonconformances; improve operational efficiency; and/or accommodate unique or unanticipated circumstances. Requests for amendments are directed from the UH Project Manager to the TCEQ TMDL Project Manager in writing using the TMDL QAPP Expedited Amendment form. The changes are effective immediately upon approval by the TCEQ TMDL Project Manager and TCEQ Quality Assurance Specialist, or their designees, and the EPA Project Officer (if applicable). Amendments to the QAPP and the reasons for the changes will be documented, and copies of the approved QAPP Expedited Amendment form will be distributed to all individuals on the QAPP distribution list by the UH QAO.

Amendments shall be reviewed, approved, and incorporated into a revised QAPP during the annual revision process or within 120 days of the initial approval in cases of significant changes.

A7 QUALITY OBJECTIVES AND CRITERIA FOR MODEL INPUTS/OUTPUTS

The project objective is to complete a model which may be used to support decisions related to TMDL development, stream standards modifications, permit decisions, and water quality assessments.

The QAPP is reviewed by the TCEQ to help ensure that data generated for the purposes described herein are scientifically valid and legally defensible. This review process will also help ensure that products submitted to the TCEQ have been analyzed in a way that guarantees its reliability.

A7-1 Data Quality Objectives

Data Quality Objectives (DQOs) are qualitative and quantitative statements that clarify the intended use of data, define the types of data needed to support a decision, identify the conditions under which the data should be collected, and specify tolerable limits on the probability of making a decision error because of uncertainty in the data. Data required will come in two main forms, that which is collected by the project team through monitoring activities and that which come from outside sources. For the most part, data from outside of the team's own monitoring activities will not require specific acceptance criteria since it is from the government sources, which have already been subjected to QA/QC procedures. That data will be checked against independently monitored measurements performed by the project team, and it may be replaced by project team data if it appears less accurate or suspect.

The data that is collected by the project team will come in two main forms

- Data that is measured and reported directly by project staff and
- Data which is measured by project staff but reported through outside contractors

Data of the first type will be flow measurements taken in tributaries and water quality parameters that can easily be measured and reported in the field in real time (e.g. pH, salinity, temperature, specific conductivity). The quality of flow data will be ascertained through multiple measurement repeatability and comparison to USGS gauges and other independent measurements wherever possible. Flow data that is not reproducible, exhibits high relative standard deviation between readings (>25%), or is simply not intuitive will be discarded. Water quality parameters will not, in most cases, need much quality assurance because most of it will not be used in any modeling efforts. Salinity is the one exception to this rule, and can be evaluated in the same manner as the flow data. If it is later determined that only a certain range of salinity is reasonable or that more strict quantitative guidelines are needed for salinity to be authoritative for use in the model, then those guidelines will be added. Data reported by outside contractors, which in this case are the labs, will be parameters such as PCB concentrations, TSS, TPH, POC, sediment characteristics, etc. The QA/QC programs at the labs approved for the project will be stringent enough to merit their use in the model. This is the case for data that was already gathered in 2002-2003 and data that will be gathered under the Monitoring Plan and Monitoring QAPP.

The use of the data can be broadly classified into data that is needed for model input and data that is generated as model output. Input data needs to be checked against acceptance criteria to ensure that accurate data goes into the model while output data is checked by way of an observed validation data set[*]. An acceptance failure in input data means that the data should be rejected. An invalidation of model output means that a problem in the modeling itself has occurred and should be traced through the process going first to the calibration parameters that were determined and then moving farther back to the input data itself if the modeling error still cannot be resolved.

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[*] The observation validation data set will subject to the same DQO as the input data described above. In most cases, this is the data reported by approved laboratories with satisfactory QA/QC protocol.

A7-2 Input Data

Table A7-1 gives the model input data. It consists of only input needed for the WASP7 water quality model since the RMA2 model has already been developed.

Table A7-9. WASP model input data requirements

Data Group	Description	Source
A	**Model Identification and Simulation Control**	Basic simulation information including variables to simulate obtained from the statement of the problem
B	**Exchange Coefficients**	
	Dispersion coefficient-water column	Calibration to salinity values
	Dispersion coefficient-pore water	Literature values
	Cross-sectional area	Channel data
	Characteristic length	Channel data
C	**Volumes**	
	For water column: number of segments and volumes for each time step	Hydrodynamic file
	For benthic segments: number of segments and volumes	Number of segments equal to water column segments, volumes calculated using site data
D	**Flows**	
	- *Surface Water*	
	Flow routing	Hydrodynamic file
	Flow time function	Hydrodynamic file
	- *Pore Water*	
	Flow routing	Conceptual model
	Flow time function	Literature values
	- *Sediment Transport*	
	Area for settling and resuspension	Channel data
	Flow routing	Conceptual model

	Velocity (settling or resuspension)	Use previous sediment load study rates, and these may be refined based on reassessment of study performed by Dr. Strom.
E	**Boundary Concentrations** Concentrations for each system at segments that import, export, or exchange water with locations outside the network	 PCB dataset collected for this project
F	**Waste Loads** Point source loadings Non-point source loadings	 NPDES permit files, future effluent sampling from direct HSC outfalls, and regressions using SIC code matching for non-measured outfalls Estimated using GIS and spreadsheets models
G	**Parameters** Spatially variable characteristics of the water body that affect the particular processes being modeled. Dissolved organic carbon concentration Fraction organic carbon of solids Total lumped first-order decay rate	 Dataset collected for this project Dataset collected for this project Literature values
H	**Constants** Organic carbon partitioning coefficient First-order loss rate constant Volatilization rate constant	 Measured effective coefficients using data collected in this project (not needed if DOC and f_{oc} are input in Data Group G) Literature values Literature values (slate to be lumped into

		single first order decay constant)
	Water column biodegradation rate	Literature values (slate to be lumped into single first order decay constant)
	Benthic biodegradation rate	Literature values (slate to be lumped into single first order decay constant)
	Photolysis rate	Literature values (slate to be lumped into single first order decay constant)
I	**Kinetic Time Functions** Not used in the dioxin model	
J	**Initial Conditions**	
	Concentration of each modeled system (PCB and TSS) for each segment	PCB dataset collected for this project

*Please note that all references to PCB concentrations imply a sum of all 209 congeners as per the monitoring plan.

A7-3 Output Data

The output data for the WASP7 model is data generated by the model that will be used to aid in calibration and that will evaluated for model validation. Assuming that the RMA2 hydrodynamics model is usable, the only output that will be of any concern is salinity concentrations and total PCBs[*].

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[*] TPH is also a potential model output. It may be a useful output parameter if in fact there exists a relationship between total PCBs and TPH, but this has not as yet been determined.

.A7-4 Performance and Acceptance Criteria

The performance and acceptance criteria are the qualitative and quantitative metrics by which the model will be evaluated. Evaluation will be determined most practically on a pass-fail type assessment (e.g. The results may be used for decision-making or they may not be used.) Secondarily, the evaluation can take on a quantitative or degree of accuracy nature in the sense that one could say that beyond a simple acceptable rating of the model, to what degree it is acceptable. Understanding the quantitative model evaluation will give a sense of the strength of the model since there are other factors in the decision-making process other than simply the technical model result. If the model is weaker in some areas of prediction (e.g. certain output parameters or certain ranges of those parameters, under certain circumstances, in certain segments of the HSC), then decision-makers would have cause to consider other factors more strongly.

It was previously stated that there are both qualitative and quantitative criteria for the model. The qualitative criteria are graphical assessments of predicted data against observed data. Two methods of performing this assessment are currently in view though others may be justifiable in time.

1. Modeler's Conceptual Judgment or "Common Sense": Volatile swings in PCB concentration in time or space and unrealistic results (e.g. negative concentrations, concentrations above a solubility limit, etc.) are scenarios where the modeler has discretion to reject results from model output and then adjust modeling to correct.
2. One-to-One Plots: The accuracy of PCB concentration predictions is paramount to this project. A mis-estimation of concentration in an area of high flow could create enormous load errors, which would give bad information for decision making. Thus, it is reasonable to make Predicted vs. Observed concentration plots with validation data sets to determine how viable the model is.

The quantitative criteria to be used are the same criteria that were used to evaluate the WASP and RMA2 modeling performed it in the Dioxin TMDL study. Four statistical criteria were used. They are given here in brief and explained in more detail in the original dioxin modeling documentation in Appendix B.

1. Correlation coefficient (r): Measures the tendency of predicted and observed values to vary linearly.
2. Model Efficiency (MEF): Measures how well a model predicts relative to the average of observations.
3. Index of Agreement (d): High value indicates that there is an agreement between the model and observations.
4. Root Mean Squared Error (RMSE): Magnitude of discrepancies between predicted and observed values.

Ideally a model validation exercise would pass all qualitative and quantitative criteria. In the case where this does not happen and the model is validated anyway, an explanation will be given as to why the model was deemed valid without complete criteria compliance.

There is the possibility that a genuine invalidation of model results will occur. In this situation, as mentioned earlier, the following sources of error will be checked in the following sequence to improve model results:

1. Software execution (Is there a problem with the software on a particular computer?)
2. Parameter entry (Were all of the input parameters entered correctly? Did all of the data from the hydrodynamic file get moved to the correct segments?)
3. Calibration parameters (Were the parameters chosen in fact reasonable? Was the calibration data set reliable?)
4. Input parameters (Do these need to be adjusted, averaged, augmented, discarded, or remeasured? Were incorrect assumptions made? If parameters were taken from

literature or experience, should those parameters actually have been measured for the HSC?)

5. Model geometry/segmentation (Do more segments needed to be created or should there be more segment layers to better visualize depth profiles?)

If these avenues have been exhausted, it is still possible that the model may be used given written limitations and qualifications of use. Such a situation would be well documented and explained though it is certainly the least desirable of alternatives.

A7-5 Intended Uses of Model Output

The key model output is the total PCB concentration in water within the HSC segments. The output will first be used to do sensitivity analyses to determine the effect of the parameters (both calibrated and input) on the final model effect. This will provide a context of understanding as to what parameters are most influential. The TMDL will then be developed using various scenarios to ascertain what allowable load will put water concentrations in all segments at the regulatory standard or better.

A8 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION

The University of Houston is the lead organization with Parsons engineering as subcontractor. Student personnel on the project will be constantly learning new skills from class and research experience. This process combined with the ability to self-teach should provide the necessary knowledge to complete the task. Parsons has extensive modeling knowledge and expertise. Their experience in specific reference to the Dioxin TMDL project provides skills that will aid in the PCB TMDL since the problems are similar in the kind of contaminant modeled and the same in the location. Thus, the experience and skills of the team should not require any special training or certifications at this time.

A9 DOCUMENTATION AND RECORDS

The University of Houston is responsible for the adapted use of the HSC RMA2 hydrodynamic model coupled with the development of a WASP7 water quality model specific for PCBs. The TCEQ project manager will be provided with all model results for both models to provide the technical information needed to establish a PCB TMDL in the HSC. The QAPP is a working document, updated yearly by design and including amendments when needed. All changes and current versions of the QAPP will be provided to the TCEQ Project Manager by the UH QAO with help from the UH Project Leader.

The documents and records that describe, specify, report, or certify activities, requirements, procedures, or results and the items and materials that furnish objective evidence of the quality of items or activities are listed in Table A9-1. The TCEQ may request records at any time and/or elect to take possession of records at the conclusion of the specified retention period.

Table A9-1. Project Documents and Records

Document/Record	Location	Retention*^{a}	Form
QAPPs, amendments, and appendices	Univ. of Houston	5 years	Paper
QAPP distribution documentation	Univ. of Houston	5 years	Paper
SOPs	Univ. of Houston	5 years	Paper
Model User's Manual or Guide (including application-specific versions)	Univ. of Houston	5 years	Paper
Assessment reports for acquired data	Univ. of Houston	5 years	Paper/Electronic
Raw data files	Univ. of Houston	5 years	Paper/Electronic
Model input files	Univ. of Houston	5 years	Electronic
Model output files	Univ. of Houston	5 years	Electronic
Model Log	Univ. of Houston	5 years	Electronic
Code Verification Reports	Univ. of Houston	5 years	Paper
Interim results from iterative calibration runs	Univ. of Houston	5 years	Electronic
Calibration Report	Univ. of Houston	5 years	Paper
Model Assessment Reports	Univ. of Houston	5 years	Paper
Progress report/CAR/final report/data	Univ. of Houston / TCEQ	3 years	Paper/Electronic

*a – After the close of the project

Greater explanation for some of these items is given below.

A9-1 Modeling Log

A modeling log will be kept to document the calibration and verification model runs that are made. Every run will be kept in enough detail for someone to duplicate the work that was done. This project will not require much coding for the modeling effort, and so the format of the modeling log will be a spreadsheet that details setup conditions used for each run along with date of the run and comments on the outcome. In addition to providing a record for later consideration, the log will prevent duplicate model runs from occurring.

A9-2 Information to be Included in Reporting Packages

At the time of writing (July 2007), the HSC PCB TMDL project consists of HSC sampling and hydrodynamic-water quality modeling program. This QAPP reports only on the modeling side of that scope, and the following documentation will be provided as part of this modeling component:

- An inventory of data input parameters for WASP7 including parameters used for model calibration, validation, and sensitivity analyses
- All hydrodynamic and water quality model input files provided both in their original format and in the format required by the RMA2 and WASP7 models (where those formats are different)
- Output results generated by the RMA2 and WASP7 models
- Compiled executable files for the current RMA2 and WASP7 models
- Quarterly progress reports
- Draft final and final technical reports documenting the data sources, methods, and finding of the hydrodynamic and water quality modeling efforts

A9-3 Data Reporting Package Format and Documentation Control

The UH Project Leader is responsible for retaining information that exists in both electronic and hardcopy formats and disseminating that information to the TCEQ Project Manager. Proper records of all of the modeling activities will be maintained such that the work could be duplicated by a knowledgeable person. The modeling activities will be distributed to the TCEQ Project Manager mainly in the forms of reports. These reports are usually quarterly and final reports which will be a combination of electronic and hardcopy formats. The reports will be archived and backed up on UH computers, and two versions identical in format to what is sent to TCEQ will also be kept at UH. Disseminations to TCEQ in formats other than the reports will be performed upon request by the TCEQ Project Manager, and there will likely be many forms of intermediary data sent to TCEQ and the project team at large whenever such data is useful in the project. This more draft form of data will be destroyed when superceding reports are issued. A summary of all documents is provided in Table A9-1.

SECTION B: MEASUREMENT AND DATA ACQUISITION

B1 SAMPLING PROCESS DESIGN

Please see the approved project Monitoring Plan and Monitoring QAPP. (Reference those documents here.)

B2 SAMPLING METHODS

Please see the approved project Monitoring Plan and Monitoring QAPP. (Reference those documents here.)

B3 SAMPLE HANDLING AND CUSTODY

Please see the approved project Monitoring Plan and Monitoring QAPP. (Reference those documents here.)

B4 ANALYTICAL METHODS

Please see the approved project Monitoring Plan and Monitoring QAPP. (Reference those documents here.)

B5 QUALITY CONTROL

Please see the approved project Monitoring Plan and Monitoring QAPP. (Reference those documents here.)

B6 INSTRUMENT/EQUIPMENT TESTING, INSPECTION AND MAINTENANCE

Please see the approved project Monitoring Plan and Monitoring QAPP. (Reference those documents here.)

B7 MODEL CALIBRATION

B7-1 Model Calibration Objectives

The parameters that need calibration are the objectives of the model calibration. These will be the same as those used in the Dioxin TMDL study. Those parameters, the way they will be calibrated, and the reason that they need calibration are given.

1. Sediment scour/settling velocities: The sediment scour/settling velocities will be calibrated using the total PCB concentrations from the calibration dataset. These rates could be measured through a sediment study performed on the HSC, but no study to this effect has been found or conducted. WASP does not estimate these rates from any parameter modeled in the system (e.g. water column shear stress), and thus it is left as a calibrated parameter. A relationship between scour and settling was assumed in the dioxin project of 2:1 settling:scour. This relationship will still be used until cause is given to change it.

2. Pore water diffusion: Pore water diffusion will be calibrated by way of total PCB concentration. This diffusion is difficult to measure, and it is preferable to calibrate it.

3. Dispersion coefficient: It will be calibrated using salinity concentrations in the water column because it is a measure of longitudinal mixing in the column.

For all of these objectives, the parameters will be calibrated via the four model statistics described in section A7. Further information into the details of how the calibration will be performed are in Appendix B..

B7-2 Frequency of Model Calibration

The model will likely only be calibrated once with a single data set. This data set will likely be the data that was taken in 2002-2003 by the Dioxin TMDL project team. More data sets would be preferable, but it is not certain at this point if more data will exist to calibrate more than once. Extra data sets will be prioritized for use in model validation rather than calibration. The reason for this prioritization is that since validation is the final step before the model is used, it is best to make certain at the final step rather than an intermediate one.

B7-3 Justification of Calibration Approach and Acceptance Criteria

The calibration approach and acceptance criteria given here are nearly the same that was used in the Dioxin TMDL. Since PCBs are of a similar contaminant class, and this project is in the same location as the Dioxin TMDL, it stands to reason that the same approach may be used. Uncovering of weaknesses in the previous approach, new challenges presented by a different contaminant, or different project needs will warrant changes in the method.

B7-4 Method of Acquiring the Input Data

Some of the input data has already been acquired from previous sampling, some will be pulled from public record, and the remainder will be sampled by the project team. See the Monitoring QAPP for further detail on data acquisition.

B7-5 Types of Output Generated by the Model Calibration

The output generated from the model calibration are the three parameters given as objectives of the model calibration and the four acceptance criteria statistics to assess calibration.

B7-6 Method of Assessing the Fit of the Calibration to the Equation

The equations used in the WASP water quality model are diffusive/dispersive/advective mass balances in 1D and 2D geometries. These equations are explained directly in Appendix B, but the calibration approach here does not assess directly a fit to the fundamental equations. The approach assesses the equation in terms of model output rather than equation examination. Thus, the equations are incorporated into the assessment in an indirect way.

B7-7 Method of Incorporating Variability and Uncertainty in the Model Calibration Results

Variability and uncertainty will be quantified and understood through the use of the sensitivity analyses. WASP7 currently has no method rigorously propagating errors in input values all the way through to model output. Therefore, an understanding of how much predictions change when calibratable parameters and model values are altered slightly will give a sense of the range of error in a prediction.

B7-8 Corrective action to be taken if acceptance criteria are not met

The corrective action sequence given in section A7 should suffice to get an acceptable calibration.

B7-9 Model Sensitivity

Sensitivity analyses will be run on the WASP7 model in order to determine the robustness of the model to changes in parameters and to determine what parameters (those that were calibrated or input) are most influential to the final result of the modeling. In keeping with conventions used in the Dioxin TMDL, sensitivity analyses will be run on each parameter at division and multiplication factors of 2, 5, and 10 wherever model results are still reasonable. The parameters currently considered are settling velocity, scouring velocity, pore water dispersivity, water column dispersivity, lumped first order decay constant (volatilization, biodegradation, photolysis), organic-carbon normalized partition coefficient, non-point source loads, point source loads, runoff loads, and upstream of model system loads. Channel spatial and temporal profiles will be generated under these conditions to see how much influence each parameter has. The source and certainty of more influential parameters will be examined to make certain of their accuracy and precision in the final validated model.

B8 INSPECTION/ACCEPTANCE OF SUPPLIES AND CONSUMABLES

Please see the approved project Monitoring Plan and Monitoring QAPP. (Reference those documents here.)

B9 NON-DIRECT MEASUREMENTS (DATA ACQUISITION REQUIREMENTS)

Table B9-1 presents a set of known data needs that will be supplied from non-direct data sources, sources that will not be directly measured by the project team. The data is taken from two main types of sources: governmental databases and literature sources.

Table B9-1 Non-direct data sources used for the WASP water quality model

Type of Measurement or Analysis	Type of Data (time series, rate, constant, statistic, taxa, etc.)	Units	Source	Quality Assurance Documentation	Use
Channel Cross-Section	Spatial	meters squared	Channel Data[a]		Model grid
Channel characteristic length	Spatial (xy)	meters	Channel Data[a]		Model grid, dispersional mixing calculation
Pore water dispersion coefficient	Constant	m^2/sec	Literature		Mixing calculation
Shore and channel line	Spatial (xy)	meters	TCEQ		Model grid
Channel depths	Spatial (z)	meters	Channel Data[a]		Model grid
Settling / resuspension areas	Spatial (xy)	meters squared	Channel Data[a]		PCB sediment transport calculation
∑PCB calibration concentrations	Time series and spatial	ng/L	TCEQ SWQM		Calibration

			database		
Rainfall	Time series and spatial	in	HCOEM[b] Website		Wet depositional load
Upstream inflows	Rate	m^3/sec	USGS Gauge Records		Boundary condition
Point source flows	Rate	m^3/sec	NPDES Records		Outside load
Lumped first order decay rate (biodegradation, photolysis, and volatilization)	Constant	1/day	Literature		Loss calculation
Organic carbon partitioning coefficient	Constant	unitless	Literature		Transport calculation

[a] Channel data sources are for the 1-D sections of the model are from the deep draft channel survey at http://beams.swg.usace.army.mil/surveys.html (HSC cross-section) and TSARP data (housed at UH) for the major tributaries. For 2-D sections of the model, bathymetry will be obtained from the Texas General Land Office at http://www.glo.state.tx.us/.

[b] Harris County Office of Emergency Management

Governmental database sources have already undergone QA/QC procedures before being posted for public use. Thus, no specific quality assurance procedure or documentation is needed to verify the quality of the data. While QA/QC documentation is not needed, an explanation for the choice of which data to use (when duplicate values exist) and the limitation of the data is necessary. In the case of Channel Data, channel geometries have been measured for many years, and the most recent measurements will be used in order to get the closest approximation to the channel as it exists today. The same is true for the TCEQ data, USGS gauge records, and

NPDES records. The most recent data is considered the valuable data source. If the most recent data is not used, an explanation will be given in the quarterly reports. Relevant data limitations on this governmental data do not exist for the most part other than the data sets that are more time-specific. USGS flow measurements, the SWQM data, and NPDES outfall flows are tied to a specific measurements in time. These data sets will be limited to those measured time periods except for purposes of estimating stream flows or outfall flows that will not be measured directly or are not known.

Literature data sources are a potential source of error in terms of what physical constants are chosen because there are often many constants that could be chosen. In the HSC PCB TMDL project, all of the literature values will be drawn from The Second Edition of Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals. (Mackay et al., 2006) The handbook lists all constants from all literature sources on PCB from 2005 and earlier. Criteria for choosing values using this data source will be frequency of the value measured from different data sources, frequency of citation of that value by other authors, and greatest similarity to the HSC system in the study that was used to get the value.

It is not yet clear if all of the data mentioned will be a complete data set for what is required. If data is missing entirely or entered incorrectly, then a method will need to be determined to compensate for the loss. In general, averaging techniques, extrapolations, and possibly literature estimations will be used to handle the missing data. Specific techniques will be described in quarterly reports or QAPP amendments if those techniques are needed.

B10 DATA MANAGEMENT AND HARDWARE/SOFTWARE CONFIGURATION

This project will have data coming from many non-directly measured sources and measured sources. In addition, that data will come in different formats determined by the organization from which the data was taken as well as the form in which the data is needed to be used in modeling and analysis. Thus, a clear understanding of what kind of data is expected (type, quality, and amount) as well as how that data is handled is vital at the front end of the project to make sure that mistakes are minimized, procedures are documented, and no data is lost over the life of the project.

The data will come in the form of binary files (WASP input, output, and configuration files), Excel spreadsheets, Access database files, geodatabase files, shapefiles, feature classes, and GIS map files. All efforts will be made to preserve data in its raw form so that it can be reassessed and mined for other purposes later in the project. The preservation of that data is important as well as the documentation of its source. To that end, a Central Data Record will be kept of all data sources used in the modeling portion of the project including information on amount, source, access period, use, and alteration (in terms of data values or data format).

Data will be reformatted according to its intended use, and all of that reformatting requires checking to make sure that it is done correctly. In the case of spatial data, all coordinates will be converted to latitude and longitude for use in GIS mapping. For modeling purposes, the software requires data to be in a certain read format as well as in the units used in the model. All data input into the WASP model will be checked against these requirements to avoid simple unit conversion errors or problems of reading incorrect rows (e.g. reading velocity value as flow values). This project is using the output from the RMA2 HSC model using for the Dioxin TMDL. In order to get that data into WASP, the HSCREAD interface is required. That interface was designed for the particular WASP model grid used in the Dioxin TMDL study. While the WASP grid will likely be very close to satisfactory for PCBs, it is likely that small changes will need. Thus, for the RMA2 output to be used as WASP input, it is likely that the HSCREAD interface code will need to be altered to ensure that it is going in the model correctly.

B10-1 Data Management

It is valuable to consider the specific data management procedures for the project in terms of the expected data products. Those products and their management are here explained.

Queried Raw Data Results: This class of data includes such examples as SWQM parameter data, rainfall data, and gauge flows. Nearly all of this type of data will be pulled from the internet or ordered from an organization. That source will be tracked, and then that data will be stored in its original format in a common location. It will need to be manipulated for the purposes of database inclusion, statistical summaries, etc. Those activities will be documented in the Central Data Record.

Input Database Files: Files that need to be manipulated as text files or spreadsheets before they are placed in a database will be stored with that database. Information about the raw file that they were made from will be included with the file.

Model Input/Output/Configuration Files: These files will be kept with the model run that they belong in their original binary format. If multiple model runs use the same input or configuration files, those runs and their unique outputs will be stored together. Those model runs that are more critical to the project outcome (e.g. the TMDL scenario, the base scenario, anything asked for specifically by stakeholders, etc.) will be kept in two locations. One will be with all of the model runs, and the other will be a second folder that denotes these special runs. This will facilitate quick access to the important runs as well as duplication of critical project data. Also these special runs will be copied into a more readable format in MS Excel so that they may be more readable for later inspection. An MS Excel spreadsheet log (modeling log) will be kept with the modeling run files so that runs can be tracked in terms of parameters, date of the run, reason for the run, conclusion on the run, etc.

Excel Calculation Spreadsheets: Spreadsheet calculations for model input formatting and model output analysis will be required. These spreadsheets will be separated and stored as either model input or model post-processing. Written explanations of what each spreadsheet does will be kept in them as a separate workbook page.

Parameter Databases: Databases containing monitoring results (taken either by the project team or gotten elsewhere) will be kept so that queries can be run, statistics generated, etc. These databases will be stored with their input files. An effort will be made to provide information on the meaning of each field name given in tables. Also queries and tables will be given consistent file naming conventions to make them easier to use by others. All null values in any database will be denoted with some easily understood marker in order to avoid erroneous zeros.

Geodatabases: From parameter databases and other sources, geodatabases will be generated that ultimately will generate output for GIS software. While parameter databases may include spatial information, it is the goal of the data storage to keep all GIS file generating database tables and queries separate from pure data analysis and storage databases.

Geofiles (GIS maps, shapefiles, feature classes): These will be stored with the geodatabase that was used to generate them. It is desirable to keep these in a folder organization scheme that makes them easy to find and easy to place in new files. Ideally, these files will rarely be moved so that links made in GIS maps will not be broken. No central GIS server will be used, so this may be a challenge.

In general, all data used in the project will be tracked from the moment that they are received so that their source, use, and location may always be known. Files or situations not anticipated by the previous list will be handled according to this general philosophy.

B10-2 Migration/Transfer/Conversion

The modeling portion of this TMDL study will likely be primarily performed by one individual working on one particular computer. Thus, file transfers that occur will be in terms of raw data submitted to that one modeler, simple reformat or spreadsheet calculations performed by others and sent to the modeler, or processed output sent to other project members or the TCEQ Project Manager. Since the modeling efforts are then localized to one individual, a detailed file transfer infrastructure is not needed. Most files will be transferred by email or through CD/DVD mailouts, and a more detailed system will only be developed if the modeling tasks becomes more divided between personnel. If that does happen or a project team member needs to run the model on their own, the computer in which the model resides can be usually be accessed remotely. The remote access should also lower the amount of file transfer required.

B10- 3 Information Dissemination

Project updates will be provided to the TMDL Project Manager in quarterly progress reports, periodic emails, and phone call meetings. The project information as it progresses will be made available at stakeholder meetings for the benefit of the TCEQ Project Manager, the stakeholders, and the general public. Input data and model outputs resulting from the project will be accessible to the general public by written request to the TCEQ.

B10-4 Hardware/Software configuration

Computers that will be used to develop the WASP model and analyze the results will be PCs running the Windows XP Professional operating system. The computer used to run the WASP model previously for the Dioxin TMDL ran with a processor of 5.32 GHz and RAM of 3 GB. The modeling computer will have that configuration or better and should provide adequate processing power for efficient model runs.

B10-5 Archives/Data Retention

Complete original data sets are archived on permanent media CD/DVDs and retained on-site by the University of Houston for a retention period specified in Table A9-1.

When the project is complete, a final report will be issued that should have most if not all of the files used in the modeling effort as a location of archival. The modeling computer will also retain the files from the project, and that retention will continue further by being transferred to another computer when the previous computer is discarded. That computer will likely always be housed at the Rifai research lab at UH Engineering. A former Schlumberger storage facility (University Business Park) containing all project data for projects at UH exists at 5000 Gulf Freeway. This facility will house boxes of hardcopy data from the project, and electronic data will be included in those files on CDs and DVDs with information on their contents. Between these three archival sources, the data should be effectively protected. As it currently stands, the policy of the research group at UH is that data is retained indefinitely.

B10-6 Backup/Disaster Recovery

The modeling computer will be backed up weekly on an external hard drive. When the model is being altered more often, the backup frequency may be changed or manual backups can then be used. The modeler running that modeling computer will be responsible for making certain that this is happening. If the modeling computer suffers catastrophic failure, the backed up files on the external hard drive may be easily moved to other available computers and run with minimal loss of time and extra effort. Total systems recovery should be able to be performed within one week’s time from the hardware failure.

SECTION C: ASSESSMENT AND OVERSIGHT

C1 ASSESSMENTS AND RESPONSE ACTIONS

The following table presents types of assessments and response action for activities applicable to this QAPP.

Table C1-1. Assessments and Response Actions

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
General				
Status Monitoring, Oversight, etc.	Continuous	UH Project Manager	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of subcontractors peformance and data quality	Report to TCEQ in Quarterly/Monthly Report. Ensure project requirements are being fulfilled.
Technical Systems Audit	Dates to be determined by TCEQ	TCEQ QAS	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP	30 days to respond in writing to the TCEQ to address corrective actions
Data Quality				
RMA2 Hydrodynamic Output		UH Project Manager, UH QAO	check that it is correct and working properly in HSCREAD	adjust RMA2 model
Point Source Locations		UH Project Manager, UH QAO	map and check xy coordinates	correct data
Channel Geography and Dimensions		UH Project Manager, UH QAO	map and check xy coordinates, check z coordinates on depths, check calculation of areas	correct data

Gathered and Directly Monitored Parameters (∑PCB, TSS, solid OC frac, Salinity, Dissolved/Suspended Splits)		UH Project Manager, UH QAO	check correct station-value associations, non-detect treatment consistency, null value treatment, outliers, erroneous results	correct data, extrapolate missing data, look for other data, log outliers
Input flows		UH Project Manager, UH QAO	check for completeness and errors	correct data, log outliers
Model Setup				
Grid Scheme		UH Project Manager, UH QAO	check representativeness of channel, check that all grid specification for each cell have been made	adjust the grid
Initial Conditions		UH Project Manager, UH QAO	check data completeness, correct time span, and entry into model	correct as needed
Boundary Conditions		UH Project Manager, UH QAO	check that all boundaries have conditions, make certain cell assignments are correct	correct as needed
Input Parameters (Koc, decay, etc.)		UH Project Manager, UH QAO	check reasonableness of parameter choice and how cell specific parameters need to be	correct as needed, search for other parameters
Time Step and Run Time		UH Project Manager, UH QAO	check that time step makes sense and that run time fits the prediction needs	adjust as needed
Hydrodynamic Linking		UH Project Manager, UH QAO	check that hydronamic inputs are going to correct cell assignments	correct as needed
Model Calibration				
Adjustable Coefficients		UH Project Manager, UH QAO	check and maintain within min/max range	adjust as needed

Model Performance and Acceptance Criteria		UH Project Manager, UH QAO	check that criteria are being applied correctly	adjust model coefficients
Model Validation				
Independence of data set		UH Project Manager, UH QAO	compare against calibration set	
Uniqueness of data set		UH Project Manager, UH QAO	check that different conditions in channel were utilized as much as possible	
Time span of data set		UH Project Manager, UH QAO	check against validation time span needs	
Model Performance and Acceptance Criteria		UH Project Manager, UH QAO	check that criteria are being applied correctly	review model coefficients
NPS and PS Load Allocation				
Runoff load		UH Project Manager, UH QAO	check that correct concentrations and flows used	correct as needed
Depositional load		UH Project Manager, UH QAO	check time series of rainfall amounts and that correct concentrations used	correct as needed
Point source selection methodology		UH Project Manager, UH QAO	check that methodology is defensible	adjust methodology
Industry point source selection and quantitation		UH Project Manager, UH QAO	check that methodology is used and that point source estimations make sense	review methodology application and possibly apply it again
Sediment Transport				

Investigation		UH Project Manager, UH QAO	check that efforts were made to determine if transport is significant, especially at boundaries	make some level of investigation
Implementation into model		UH Project Manager, UH QAO	check that any needed sediment transport into model is quantitatively and conceptual correct	rethink implementation and correct quantitation estimates/values
Tech. Memoranda and Reports				
Findings		UH Project Manager	review and approve; review and request changes	edit report(s) as needed
Conclusions		UH Project Manager	review and approve; review and request changes	edit report(s) as needed
TMDL Determination				
Tech. Credibility of Model		UH Project Manager, UH QAO	assess & certify model for TCEQ TMDL needs	
Updating				
Progress Reports	Quarterly	UH Project Manager	summarize efforts and identify problems and response to the problem	
Stakeholder Meetings		UH Project Manager	make sure all relevant information presented effectively at the meeting, address questions from stakeholders	

C1-1 Internal Assessment

Since the project is primarily a modeling endeavor, traditional performance and system audits are not appropriate. Instead, the data generated as part of the modeling results will be evaluated during the validation and model output interpretation processes. Modeling performance assessments will be made continually by the contractor and the TCEQ TMDL Program as described in the validation and calibration processes, and by evaluation of tasks listed in Table D2-1.

Modeling data and project deliverables will be internally quality controlled by the TMDL Project Manager's in-house review. The Project Manager will maintain overall responsibility for examining the contracted work to ensure methodologies and processes are consistent with the procedures outlined in this QAPP.

What was given in the previous table is a list of very specific assessments that apply to this project. UH is the lead organization, and thus the UH Project Manager will be primarily responsible for all internal assessments. There are three broad assessments that cover the scope of everything shown in C1-1:

1) Surveillance Activities: To ensure that the technical aspects of the effort are being properly implemented, the status and progress of all work performed by the UH for the development of water quality model of the HSC will be closely monitored by the UH Project Manager. The UH Project Manager, in turn, will keep the Principal Investigators informed of the status of work during the course of the project. If, based on monitoring of the activities of the project, problems arise that could impact the ability of the project team to achieve the goals of the project, then appropriate corrective actions will be identified and implemented jointly by the UH Project Manager.

2) Data Acquisition: Data will be acquired for the project in its initial stages by way of data download and through the data collected from the Monitoring QAPP. As discussed in other portions of this QAPP, that data is needed for model input, configuration, calibration, and validation. The data will be run through the acceptance criteria given in the Data Quality Objectives of section 0. As data is brought in and organized, checks will be made to flag

incomplete and erroneous data as well as data that needs to have units converted for input into WASP. All conversions and other data manipulations (e.g. interpolating, averaging, truncating, etc.) will be documented. The various data sets will also be assessed to check the magnitudes and numerical ranges of the data to identify, and eliminate, any apparent outliers in the acquired data sets with appropriate consultation with project participants. Because many data sets used in building surface water models typically conform to a Gaussian (normal) distribution, outliers are defined as values determined to be less than, or greater than, the numerical range defined by three standard deviations from the mean value. No outlier data will be excluded from the input, or calibration and validation, data sets without due process. The TCEQ Project Manager will make final decisions related to the disposition of outlier data. As the final step in the assessment of data acquired for the project, georeferenced data (e.g., locations of monitoring stations or wastewater discharges), will be checked to ensure that the geographical position of the data is correctly located within the spatial domain of the hydrodynamic model. Corrections will be made, as needed, to assign the georeferenced data to the correct latitude and longitude position.

3) Model Calibration and Validation: During calibration and validation phases, assessments will be made as to the appropriateness of the range of values assigned to adjustable model parameters.

The assessor for this project will be the UH Project Leader. Project oversight will be provided by the TMDL Program of TCEQ. Others are available for technical assistance as requested, including project staff from UH, technical staff in the TCEQ TMDL Program and the TCEQ QA Officer. The TCEQ Project Manager has the ultimate authority to continue, or modify work, in a significant fashion, including issuance of a stop work order.

The UH Project Leader is responsible for modifying conditions to achieve results which (s)he believes are realistic and supportable by actual conditions, and which would reflect probable results should future sampling be undertaken in attempts to develop a post-audit model of the water quality of the HSC. The UH Project Leader will maintain a electronic journal record (i.e., modeling log), such that input and output of computer analyses at various steps in the development of the model can be tracked and reproduced if necessary.

C1-2 Corrective Action

The UH Project Manager is responsible for implementing and tracking corrective action procedures as a result of audit findings. Records of audit findings and corrective actions are maintained by the TCEQ Project Manager and UH Quality Assurance Officer. Corrective action documentation will be submitted to the TCEQ TMDL Project Manager with the progress report.

If audit findings and corrective actions cannot be resolved, then the authority and responsibility for terminating work is specified in agreements or contracts between participating organizations.

The UH Project Manager and/or the UH Quality Assurance Officer is responsible for documenting deficiencies and nonconformances and reporting these to their management. A Corrective Action Report (CAR) must be completed and submitted to the TCEQ with the next progress report due after the deficiency and/or nonconformance occurred.

C2 REPORTS TO MANAGEMENT

C2-1 Reports to University of Houston Project Management

Reports to UH Project Management will happen on a weekly to biweekly basis, and be in the form of face-to-face meetings and emails. Project status will be presented in a discussion format as well as in hardcopy data output, summary, analysis formats as needed. Email will often be used for communication which will provide a written record of what has transpired, but individuals in the UH Project Team will also be encouraged to keep notes on meetings and other communications as well.

C2-2 Reports to TCEQ Project Management

Telephone calls, emails, and conference calls are the best way for the UH Project Manager to keep the TCEQ Project Manager apprised of progress and results on the goals of the modeling project. Formal deliverables that can be expected by the TCEQ Project Manager include:

1. This QAPP document (in its most recent format including formal amendments)
2. Quarterly Progress Reports (including CARs when appropriate)
3. WASP model input and output files
4. Current version of the WASP executable file
5. Draft report
6. Final report

A more detailed explanation of some of these deliverables is given below.

Quarterly/Monthly Progress Report – Briefly details the University of Houston activities for each task; reports problems, delays, and corrective actions; and outlines the status of each task's deliverables. Reports should provide enough information so the TCEQ Project Manager can evaluate the modeling effort.

Corrective Action Report (CAR) – Identifies any deficiencies and nonconformances. The cause(s) and program impacts are discussed. The completed corrective actions are documented. Report is submitted to the TCEQ TMDL Project Manager with the first progress report occurring after the deficiencies and/or nonconformance was identified.

Audit Report and Response - Following any audit performed by the UH, a report of findings, recommendations and responses are sent to the TCEQ project manager in the quarterly/monthly progress report. Such reports will include model performance assessments, calibration, and validation performance determination.

C2-3 Reports by TCEQ Project Management

Contractor Evaluation - The UH is evaluated in a Contractor Evaluation by the TCEQ annually for compliance with administrative and programmatic standards. Results of the evaluation are submitted to the TCEQ Financial Administration Division, Procurements and Contracts Section.

SECTION D: DATA VALIDATION AND USABILITY

D1 DEPARTURES FROM VALIDATION CRITERIA

The UH Data Manager will be responsible for ensuring that all data are properly reviewed and verified, and submitted in the required format to the TCEQ Project Manager. The UH QAO is responsible for validating the data. Finally, the UH Project Manager, with the concurrence of the UH QAO, are responsible for validating that all data to be reported meet the objectives of the project and are suitable for reporting to TCEQ.

Section A7 describes a method to evaluate the model results using qualitative graphical methods and quantitative statistical methods. Both parts of this method have an appreciable amount of human judgment in them. The quantitative statistics are fairly objective though these statistics may be passed over if the model is still judged as valid. This area and the qualitative graphical analysis are both areas of subjectivity. To ensure that the model is still applied fairly and consistently, the UH QAO will make the judgment decision on the usability of the model in light of the acceptance criteria. The QAO will be under the oversight of the UH Data Manager while in this role. TCEQ project manager will also look at the criteria used for model approval and how it was applied to make a final acceptance decision so that results may be used for TMDL decision-making.

If the QAPP procedure for validation is not followed, then significant prediction errors can result. The main model output currently proposed is the total all congener PCB water concentration[1]. Model errors in validation or calibration can affect both model performance and

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[1] Sediment and fish concentrations are important in the monitoring QAPP as well as in the final decision-making procedures in the TMDL. WASP, however, only predicts the water concentrations of PCBs as the model will currently be formulated. Sediment concentrations measured in the field will be used as inputs to this model while fish concentrations will be predicted from the model water concentrations. Thus, in the case of fish concentrations,

model application. In areas of model performance, Table D1-1Table shows the following consequences that may result from the validation criteria not being met. The list is not meant to be exhaustive but rather representative of possible model issues.

Table D1-1. Consequences of unmet model validation criteria

Model Issue	Source	Application Result
Model unable to deal with high point source loads	Calibration data set was too narrow in it's variety of point source conditions	Important load scenario cannot be considered.
Model unable to deal with high runoff loads	Calibration data set was too narrow in it's variety of rainfall conditions	High rainfall patterns cannot be considered using the model.
Certain range of concentrations not predicted consistently	Calibration data set did not include that range of concentrations	That concentration range cannot be trusted when making decisions.
Unreasonably high suspended PCB concentrations	Scour velocity was calibrated at too high a value	The effects of sediment cannot be considered as completely.
PCB concentrations spatially invariant	Dispersive mixing was calibrated at too high a value	High PCB impact areas cannot truly be ascertained.

As can be seen, there are significant limitations on the use of the model when any of these or other issues occur. A problem involving inaccurate scenarios means that a TMDL decision might be considered more accurate under certain conditions than others. Inaccurate or questionable concentrations (especially when those errors are not quantifiable) create a situation

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the predicted water concentrations converted to predicted fish concentrations will be compared against actual measured fish concentrations.

where the project implementation of particular load reduction strategy might not have enough of an effect to meet the water quality standard. Errors in calibration mean that intrasystem transport interactions are not being modeled realistically. In the case of the unreasonably high suspended sediment concentrations, the bioavailable PCB concentration could be overestimated leading to an overestimation of the effect on fish and by extension an overestimation of human health risk.

A good understanding of the potential decision errors that can be made through improper application of validation acceptance criteria or through improper model performance issue analysis (i.e. not pursuing a model issue to its root cause) will give the project team an appreciation for the need to validate the model correctly. With that understanding, areas where the model is near out-of-compliance or barely out-of-compliance can be dealt with appropriately.

D2 VALIDATION METHODS

D2-1 Model Validation

Deviations in the model components will be determined through the calibration and validation process. Most of this process has already been described, but it will here be summarized in full form for conceptualization.

Input data, calibration data, and validation data will be collected either from previous records, literature, RMA2 modeling, or future sampling efforts. The compiled input parameters will be placed in the WASP7 module with geometries appropriate to describe the HSC. This geometry may need to be initially adjusted upon efforts to get the model to run. Once the model is running, the three parameters given in section B7 will be calibrated using the 2002-2003 PCB dataset taken from the Dioxin TMDL project. (Analyze data available to see what kind of timespan can be generated for the calibration period.) The monitoring data will then be used to validate the calibrated model. Hopefully, at least two datasets taken under different conditions will be generated for the validation runs. In both the calibration and validation steps, the acceptance criteria will be that given in section A7. Also both steps are subject to a certain level of optimization in calibration parameters to get the best parameterization possible.

The staff and management of the UH are responsible for the integrity, validation and verification of the data each task generates or handles throughout each process.

Verification, validation and integrity review of data will be performed using self-assessments and peer review, as appropriate to the project task, followed by technical review by the manager of the task. The data to be verified are evaluated against project specifications (Section A7) and are checked for errors, especially errors in transcription, calculations, and data input. Duplication of data leading to independent data sets with potentially conflicting values will be eliminated by having a master copy of data kept on a computer at the UH. Data retrieval will be made from that machine, and the official data version will reside there with proper electronic backup. Potential outliers are identified by examination for unreasonable data, or identified using computer-based statistical software. If a question arises or an error or potential outlier is identified, the manager of the task responsible for generating the data is contacted to resolve the issue. Issues which can be corrected are corrected and documented electronically or by initialing and dating the associated paperwork. If an issue cannot be corrected, the task manager consults with higher level project management to establish the appropriate course of action, or the data associated with the issue are rejected.

Table D2-1. Model Validation/Calibration/Verification Processes

Assessment Activity	Approximate Schedule	Responsible Party	Scope	Response Requirements
General				
Status Monitoring, Oversight, etc.	Continuous	UH Project Manager	Monitoring of the project status and records to ensure requirements are being fulfilled. Monitoring and review of subcontractors peformance and data quality	Report to TCEQ in Quarterly/Monthly Report. Ensure project requirements are being fulfilled.
Technical Systems Audit	Dates to be determined by TCEQ	TCEQ QAS	The assessment will be tailored in accordance with objectives needed to assure compliance with the QAPP	30 days to respond in writing to the TCEQ to address corrective actions
Data Quality				
RMA2 Hydrodynamic Output		UH Project Manager, UH QAO	check that it is correct and working properly in HSCREAD	adjust RMA2 model
Point Source Locations		UH Project Manager, UH QAO	map and check xy coordinates	correct data
Channel Geography and Dimensions		UH Project Manager, UH QAO	map and check xy coordinates, check z coordinates on depths, check calculation of areas	correct data
Gathered and Directly Monitored Parameters (∑PCB, TSS, solid OC frac, Salinity, Dissolved/Suspended Splits)		UH Project Manager, UH QAO	check correct station-value associations, non-detect treatment consistency, null value treatment, outliers, erroneous results	correct data, extrapolate missing data, look for other data, log outliers
Input flows		UH Project Manager, UH	check for completeness and errors	correct data, log outliers

		QAO		
Model Setup				
Grid Scheme		UH Project Manager, UH QAO	check representativeness of channel, check that all grid specification for each cell have been made	adjust the grid
Initial Conditions		UH Project Manager, UH QAO	check data completeness, correct time span, and entry into model	correct as needed
Boundary Conditions		UH Project Manager, UH QAO	check that all boundaries have conditions, make certain cell assignments are correct	correct as needed
Input Parameters (Koc, decay, etc.)		UH Project Manager, UH QAO	check reasonableness of parameter choice and how cell specific parameters need to be	correct as needed, search for other parameters
Time Step and Run Time		UH Project Manager, UH QAO	check that time step makes sense and that run time fits the prediction needs	adjust as needed
Hydrodynamic Linking		UH Project Manager, UH QAO	check that hydronamic inputs are going to correct cell assignments	correct as needed
Model Calibration				
Adjustable Coefficients		UH Project Manager, UH QAO	check and maintain within min/max range	adjust as needed
Model Performance and Acceptance Criteria		UH Project Manager, UH QAO	check that criteria are being applied correctly	adjust model coefficients
Model Validation				
Independence of data set		UH Project Manager, UH QAO	compare against calibration set	

Uniqueness of data set		UH Project Manager, UH QAO	check that different conditions in channel were utilized as much as possible	
Time span of data set		UH Project Manager, UH QAO	check against validation time span needs	
Model Performance and Acceptance Criteria		UH Project Manager, UH QAO	check that criteria are being applied correctly	review model coefficients
NPS and PS Load Allocation				
Runoff load		UH Project Manager, UH QAO	check that correct concentrations and flows used	correct as needed
Depositional load		UH Project Manager, UH QAO	check time series of rainfall amounts and that correct concentrations used	correct as needed
Point source selection methodology		UH Project Manager, UH QAO	check that methodology is defensible	adjust methodology
Industry point source selection and quantitation		UH Project Manager, UH QAO	check that methodology is used and that point source estimations make sense	review methodology application and possibly apply it again
Sediment Transport				
Investigation		UH Project Manager, UH QAO	check that efforts were made to determine if transport is significant, especially at boundaries	make some level of investigation
Implementation into model		UH Project Manager, UH QAO	check that any needed sediment transport into model is quantitatively and conceptual correct	rethink implementation and correct quantitation

				estimates/values
Tech. Memoranda and Reports				
Findings		UH Project Manager	review and approve; review and request changes	edit report(s) as needed
Conclusions		UH Project Manager	review and approve; review and request changes	edit report(s) as needed
TMDL Determination				
Tech. Credibility of Model		UH Project Manager, UH QAO	assess & certify model for TCEQ TMDL needs	
Updating				
Progress Reports	Quarterly	UH Project Manager	summarize efforts and identify problems and response to the problem	
Stakeholder Meetings		UH Project Manager	make sure all relevant information presented effectively at the meeting, address questions from stakeholders	

The UH Project Manager and QAO are each responsible for validating that the verified data are scientifically valid, legally defensible, of known precision, accuracy, integrity, meet the data quality objectives of the project, and are reportable to TCEQ. One element of the validation process involves evaluating the data again for anomalies. The UH QAO or Project Manager may designate other experienced water quality and/or modeling experts familiar with the water bodies under investigation to perform this evaluation. Any suspected errors or anomalous data must be addressed by the manager of the task associated with the data, before data validation can be completed.

A second element of the validation process is consideration of any findings identified during the monitoring systems audit conducted by the UH QAO or TCEQ QAS assigned to the project. Any issues requiring corrective action must be addressed, and the potential impact of these issues on previously collected data will be assessed. Finally, the UH Project Manager, with the concurrence of the QAO validates that the data meet the data quality objectives of the project and are suitable for reporting to TCEQ.

D3 RECONCILIATION WITH USER REQUIREMENTS

The results of the water quality monitoring study of the HSC will be review by the UH Project Leader to assess the usability of the model results, in light of any QA/QC issues identified, to provide water quality model results for determination of the TMDL load allocations that will be developed by TCEQ. Output data generated with the HSC model will be presented in the project deliverables as graphical comparisons of observed and model-generated water quality constituents. Model-data comparisons will be prepared as time series plots and as in-channel spatial plots in order to show both the model's ability to predict far out in time and the consistency with which it can predict over the whole portion of the HSC. The qualitative visual evaluation of model performance will be complemented by a quantitative numerical evaluation of model evaluative statistics where model performance will be assessed based on filtering sub-sets of model results and observed data for the critical time period/season and low-flow and high-flow hydrologic conditions. The determination of model statistics based on filtered sub-sets of observations and model results will facilitate an evaluation of the usability of the model results for the TMDL process by separating out the effects of either low-flow or high-flow conditions and/or variations in seasonality (i.e., winter vs. summer, rainy vs. dry).

Using the qualitative-quantitative approach discussed in Section A7, a determination will be made of the overall technical credibility of the HSC model framework. If the visual comparison of model results with observations appears to be in reasonable agreement and the model statistics show that the model can meet the target criteria for a state variable for a range of flow, season, and rainfall conditions then the model will be considered to be technically defensible, and therefore useable, to provide water quality model results for determination of load allocations by TCEQ for a TMDL for PCBs in the HSC.

Potential limitations of the model would result mainly from small set of calibration/validation data. The model may be able to pass both the calibration and validation criteria with the data sets chosen. The range of pollutant loadings and hydrologic conditions (e.g. rainfall, tidal occurrences, boundary condition stream flows) that are present in those data sets will serve as a practical limitation to model usage. Also, the model may have limitations concerning more distant predictions in time from the validation data. These limitations could result from changes in actual HSC geometry caused by dredging or large flood events as well as the simple conceptual limitation of accepting model results far from any measured data point. Despite these potential limitations, the model may, in fact, be quite capable of reproducing observations quite well over a wider range of conditions and time than may be able to be tested during model development. In the absence of a comparison of model results to observations for an evaluation of model performance, such potential limitations on the use of the model results would be reported qualitatively in a narrative form to TCEQ.

If performance measures of the hydrodynamic and water quality model do not meet the project's requirements for Data Quality Objectives as outlined previously, the input data and the observed data sets used to construct the water quality model and the assignment of adjustable model parameters will be carefully reviewed and re-evaluated to determine the reasons for failure to meet the performance criteria. Decisions will be made by the UH Project Leader about the (a) validity of the input data and observed data used to construct the model and the (b) steps needed to complete development of the model to achieve satisfactory performance. If, after checking data used to build the model, satisfactory performance is not achieved then a discussion of the possible explanations for the poor performance of the model will be presented and discussed in the deliverable report. Assuming that the model may still be applied for a TMDL determination even though the model may not achieve the desired level of performance, then a higher margin of safety would be used to estimate load allocations to compensate for the poor performance.

No decisions will be made by the project team based on the model predictions. These data may be subsequently analyzed and used by the TCEQ for TMDL development, stream standards modifications, permit decisions, and water quality assessments.

SECTION E: REFERENCES

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APPENDIX A. EXAMPLE LETTER

TO: *(name)*
(organization)

FROM: *(name)*
(organization)

RE: TMDL Project Title

Please sign and return this form by (*date*) to:

(*address)*

I acknowledge receipt of the referenced document(s). I understand the document(s) describe quality assurance, quality control, data management and other technical activities that must be implemented to ensure the results of work performed will satisfy stated performance criteria. My signature below indicates commitment to follow the procedures in this QAPP.

Signature Date

APPENDIX B. MODEL ACCEPTANCE CRITERIA EXCERPT EXPLANATION FROM DIOXIN TMDL QUARTERLY REPORT OF MARCH 2006

In addition to the plots previously presented a variety of model statistics were calculated to measure model performance. These are discussed in Stow et al. (2003) and Legates and McCabe (1999) and include:

1. the correlation coefficient of model predictions and observations, *r*:

$$r = \frac{\sum_{i=1}^{n}(O_i - \overline{O})(P_i - \overline{P})}{\sqrt{\sum_{i=1}^{n}(O_i - \overline{O})^2 \sum_{i=1}^{n}(P_i - \overline{P})^2}}$$

(3.4)

2. the model efficiency, *MEF*:

$$MEF = \frac{\sum_{i=1}^{n}(O_i - \overline{O})^2 - \sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2}$$

(3.5)

3. the index of agreement, *d*:

$$d = 1.0 - \frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}(|P_i - \overline{O}| + |O_i - \overline{O}|)^2}$$

(3.6)

4. the root mean squared error, *RMSE*:

$$RMSE = \frac{\sqrt{\sum_{i=1}^{n}(P_i - O_i)^2}}{n}$$

(3.7)

where n=number of observations, O_i=ith of n observations, P_i=ith of n predictions, and $\overline{O}$ and $\overline{P}$ =observation and prediction averages, respectively.

The correlation coefficient, r, ranges from –1 to 1 and measures the tendency of the predicted and observed values to vary together linearly[‡‡]. The model efficiency, *MEF*, measures how well a model predicts relative to the average of observations; a value close to 1 indicates a good match between observations and model predictions. The index of agreement, d, varies from 0 to 1, with higher values indicating better agreement between the model and observations. Finally, the root mean squared error, *RMSE*, measures the magnitude of the discrepancies between predicted and observed values, with values close to zero indicating a good match.

[‡‡] This parameter is equivalent to the square root of the coefficient of determination (r^2) of the best-fit-line.