Total Maximum Daily Loads for PCBs in the Houston Ship Channel

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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 the Texas Department of State Health Services (TDSHS) to issue seafood consumption advisories, and some of these advisories have been issued for the Houston Ship Channel (HSC). Three 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 Morgan's Point. In addition to these two finfish advisories, the TDSHS issued ADV-35 (for PCBs and dioxins) that advises against consumption of gafftopsail catfish and speckled trout in upper Galveston Bay, lower Galveston Bay, and Trinity Bay. These advisories represent a large surface water system for which a PCB TMDL needs to be developed and implemented. 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. Though ADV-35 covers surface water beyond upper Galveston Bay, the TMDL boundary is currently set for upper Galveston Bay. Tasks performed under this work order include monitoring and data collection, data evaluation and analysis in the Houston Ship Channel. Chapter 2 of this report presents the monitoring and data collection activities

conducted in Spring and Summer 2008. Chapter 3 presents data evaluation activities undertaken to date while Chapters 4 and 5 provide the results obtained thus far.

2. MONITORING AND DATA COLLECTION

The task encompasses monitoring and data collection activities to assess current levels of PCBs in the Houston Ship Channel (HSC) system. This section summarizes the progress made between September 1, 2007 and August 31, 2008 regarding sampling activities. In addition, the chapter includes a summary of the sampling results and presents an analysis of the gathered data.

To date 37 water sampling locations, 70 sediment sampling locations, and 26 locations for fish have been sampled. A description of the methods and technical approach undertaken during sampling activities is given below. All the sampling and analysis procedures used followed to the most part the approved project QAPP, and greater detail on sampling procedures and sampling rationale is given in the project QAPP as well.

2.1 Summary of Monitoring and Collection Activities

The purposes of the sampling task are to assess the spatial and temporal extent of PCBs and to determine whether water quality is improving or deteriorating for the Surface Water Quality Monitoring (SWQM) segments of interest. The goals with the sampling data results are: (i) to use the data results to verify whether PCB concentrations are above the water, sediment, or tissue quality criteria[*] and where, and how much PCB levels must decline to meet the criteria if it is exceeded, (ii) to identify historical increases and declines in PCB levels that may be related to changes in sources over time, and (iii) to provide PCB datasets that could be used for reliable water quality predictions through modeling.

[*] The official criteria to be used for this TMDL have not yet been decided upon. All text references, figures, and tables that use criteria up to this point have been for the purposes of providing a reference level by which to judge sampling results.

The 2008 sampling was conducted in three phases: an initial all-media sampling phase (water, sediment, and fish) over the entire study area, a sediment intensive phase consisting of sediment-only collection in segments 1006, 1007, and adjacent tributaries (Sediment Intensive Phase), and an additional fish gathering phase to increase the diversity of species collected (Additional Species Phase).

The all Media Phase included 25 locations for sediments, 37 locations for ambient water, and 26 locations for fish tissue (Figures 2.1, 2.2, and 2.4, respectively). The Sediment Intensive Phase included 45 sites (see Figure 2.3) in segments 1006 and 1007 and was intended to gather spatial detail for PCB in sediments for the two segments. The Additional Species Phase collected other types of fish beside catfish from 9 locations to provide diversity in the species studied. Tables 2.1 and 2.2 include a summary of the total number of samples collected during FY2008 sampling activities.

Table 2.1 Summary of samples collected for PCB analysis

Matrix		**Spring-Summer 2008**		
		# of sites	**QC samples***	**Total # of samples**
Water	XAD column	37	9	46
	GFF	37	8	45
In-stream sediment		70¶	15	100
Fish tissue	Cat fish	26	5	31
	Trout/Croaker	20	1	21
	Yellowfin Tuna	0	1	1

* QC samples include field duplicates, field blanks, equipment rinse blanks, and recovery columns specified in the QAPP.

¶ 15 samples were collected along a transect at the same site in addition to the parent sample.

Table 2.2 Summary of samples collected for conventional parameter analysis

Matrix		Parameter	Spring 2008		
			# of sites	QC samples*	Total # of samples
Water		TSS, TPH, DOC	37	7	44
In-stream sediment		TPH, TOC, Grain size, Solids content	70¶	15	100
Fish tissue	Cat fish	Lipid and moisture content	26	5	31
	Trout/Croaker	Lipid and moisture content	20	1	21
	YellowfinTuna	Lipid and moisture content	0	1	1

* QC samples include field duplicates, field blanks, equipment rinse blanks, and recovery columns specified in the QAPP.

¶ 15 samples were collected along a transect at the same site in addition to the parent sample.

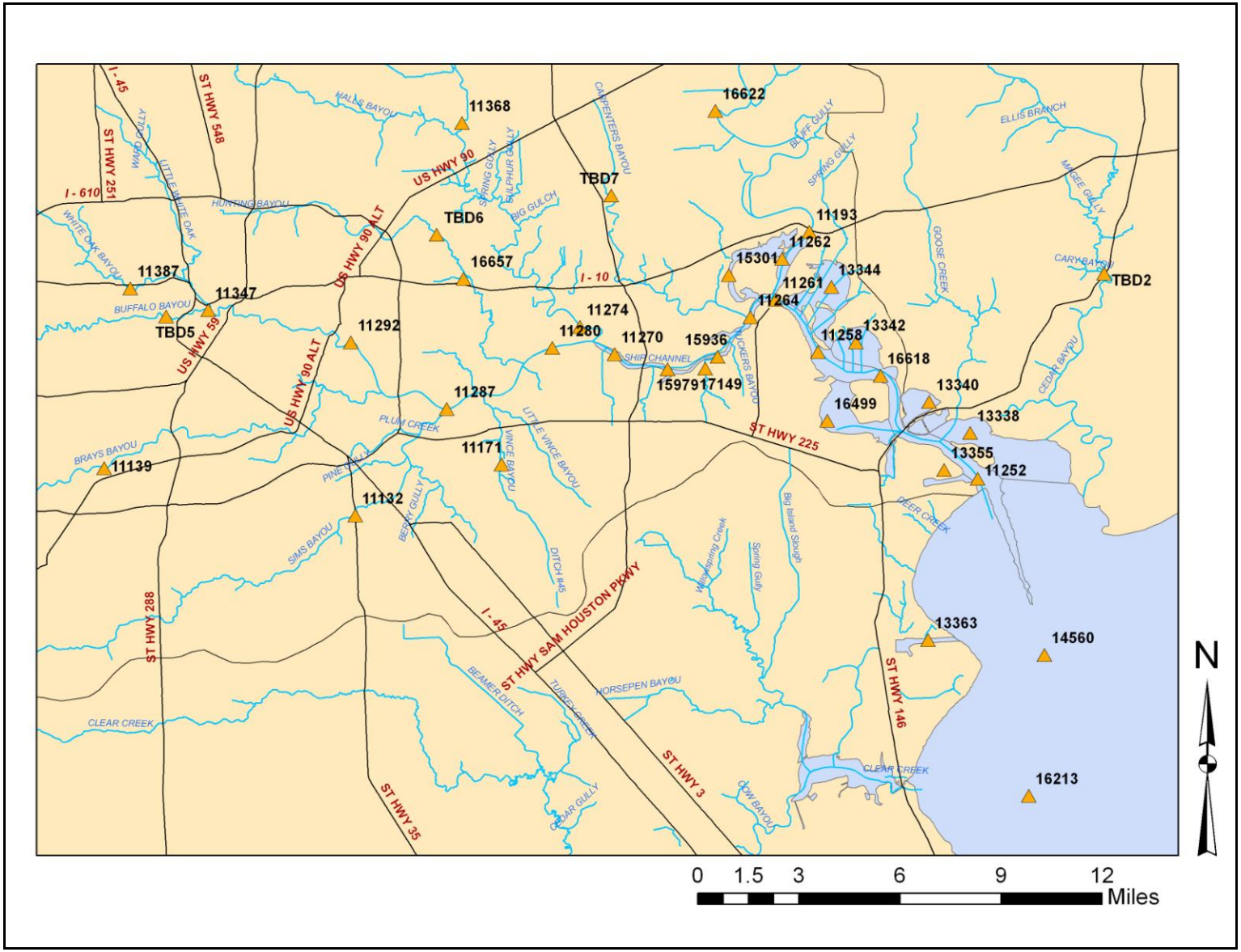

Figure 2.1 Locations for dry weather water sampling (Spring-Summer 2008)

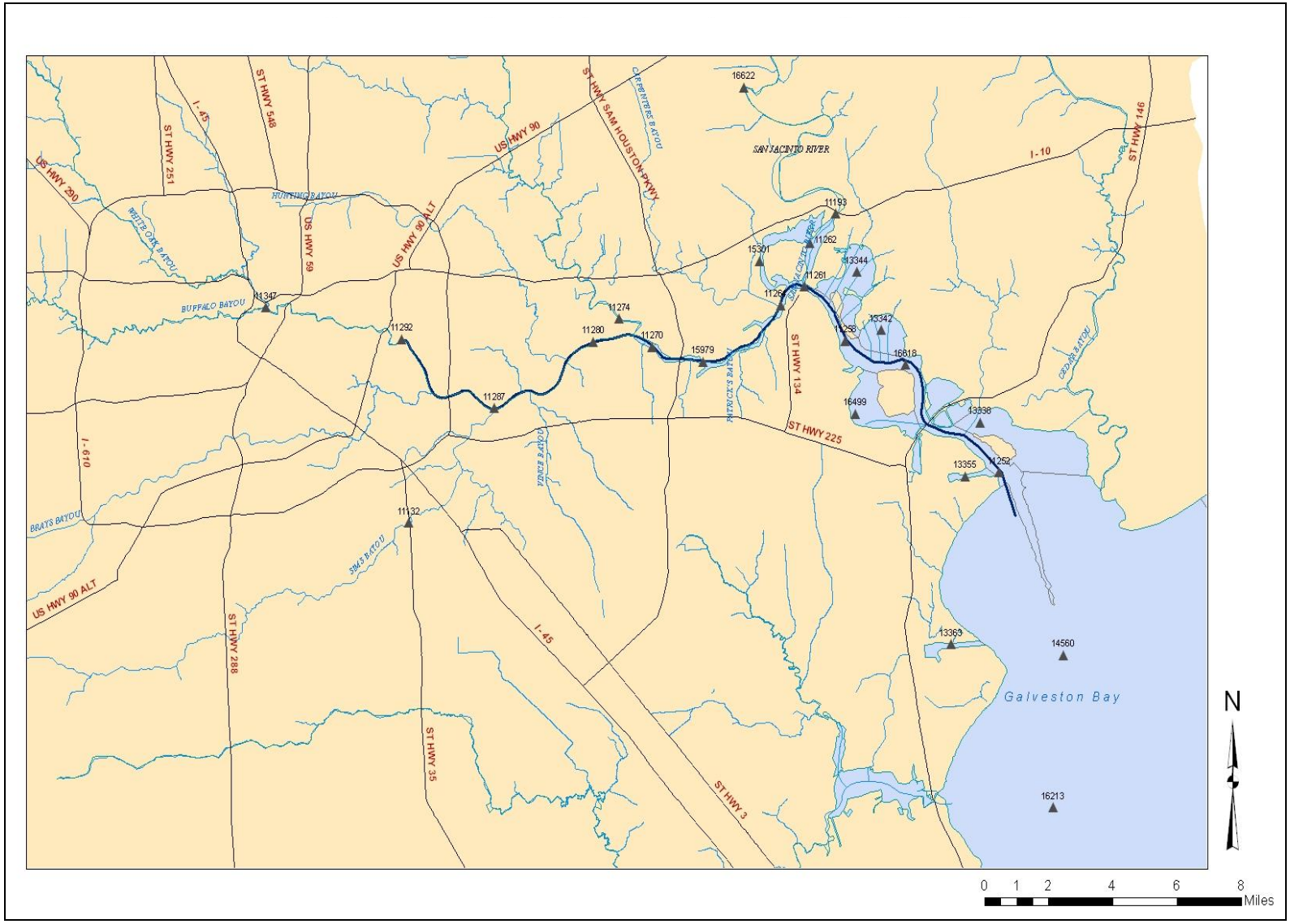

Figure 2.2 Locations for sediment sampling in the All Media Phase (Spring 2008)

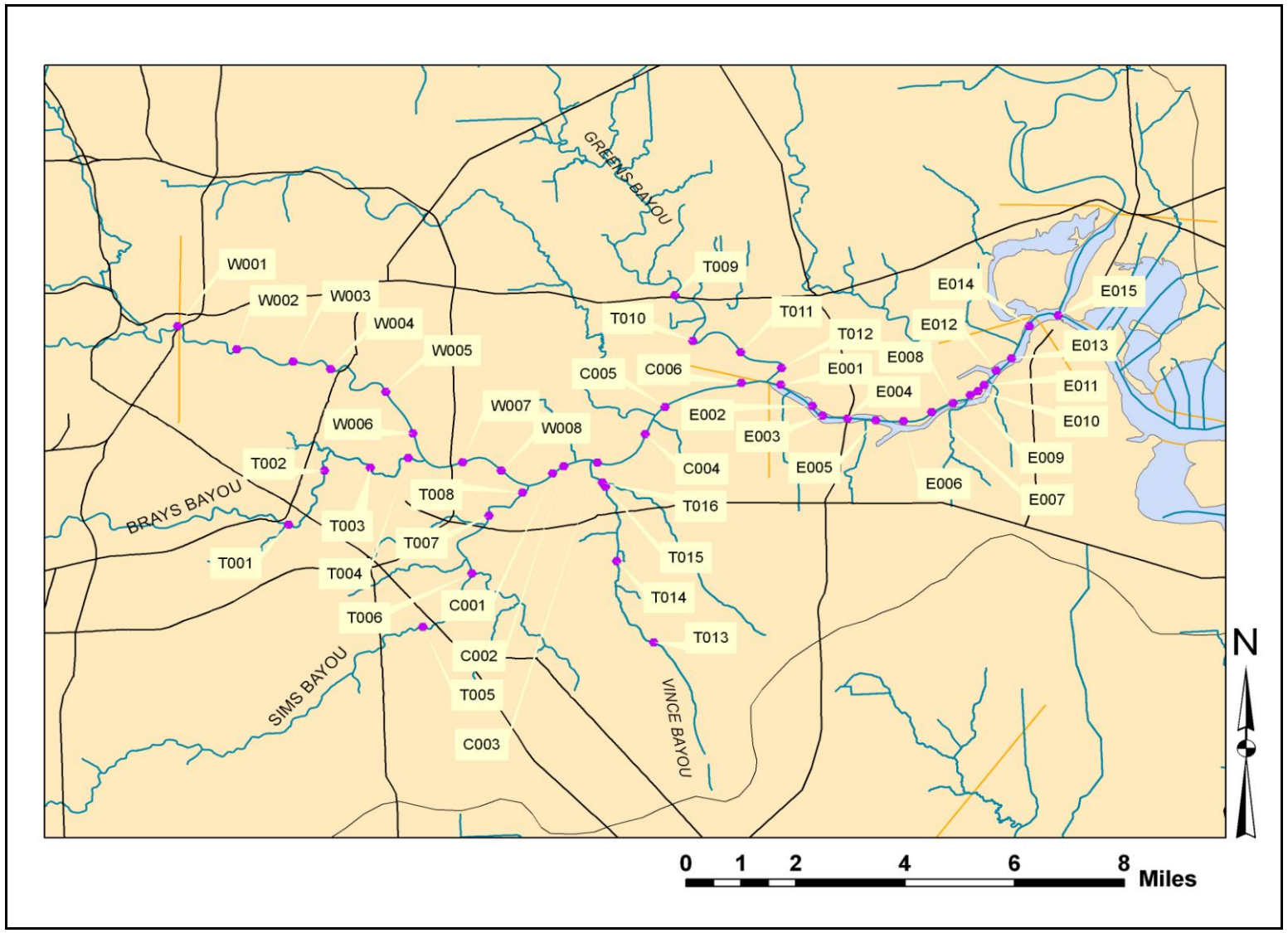

Figure 2.3 Locations for intensive sediment sampling

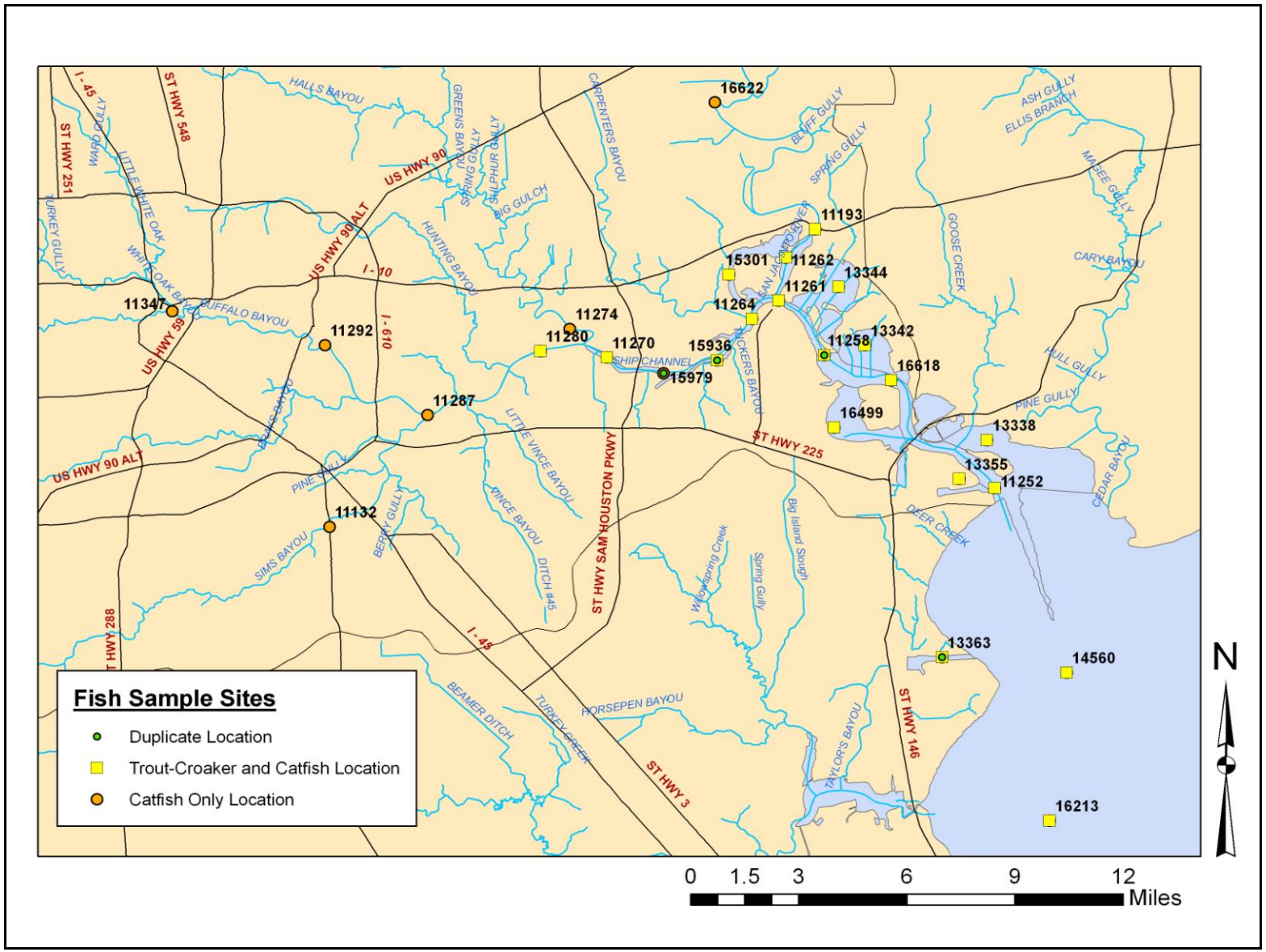

Figure 2.4 Locations for fish sampling

The following sections present a detailed summary of the sampled sites and media during Spring and Summer 2008.

2.1.1 In-stream Water Quality Sampling

Since PCB concentrations in water are significantly lower than the analytical detection limit, water sampling was conducted using the high-volume technique. The use of this technique concentrates PCBs from large volumes of water to obtain measureable quantities. Figure 2.5 shows that the high-volume system uses a stainless steel column packed with hydrophobic polymeric XAD2 resin beads through which large volumes of water can be passed. Because PCBs are very hydrophobic, they rapidly sorb to the resin, making it possible to completely collect the dissolved PCBs from the sampled water. The PCBs can then be recovered from the resin by extraction with a nonpolar organic solvent in the laboratory. PCBs associated with suspended particulates are collected on a 1 μm glass fiber filter (GFF) that contacts the sample prior to the resin. The GFF, like the XAD-2 resin, is analyzed in an HRGC/HRMS after extraction. For this TMDL, the project team used a commercially-available Infiltrex 300 high-volume sampling system[†]. The Infiltrex 300 system is primarily comprised of the following components:

- An in-line pre-filter (140 μm) to remove debris and plankton larger than 140 μm that has the capability to foul the system and damage the pump head
- A stainless steel positive displacement pump
- Glass fiber filter cartridges (1 μm effective pore size)
- A pressure gauge prior to the filter cartridge to help in preventing the filter from clogging

[†] http://www.axystechnologies.com/products/infiltrex.asp

- XAD-2 resin column
- A digital display unit displaying the pumping rate in rpms.

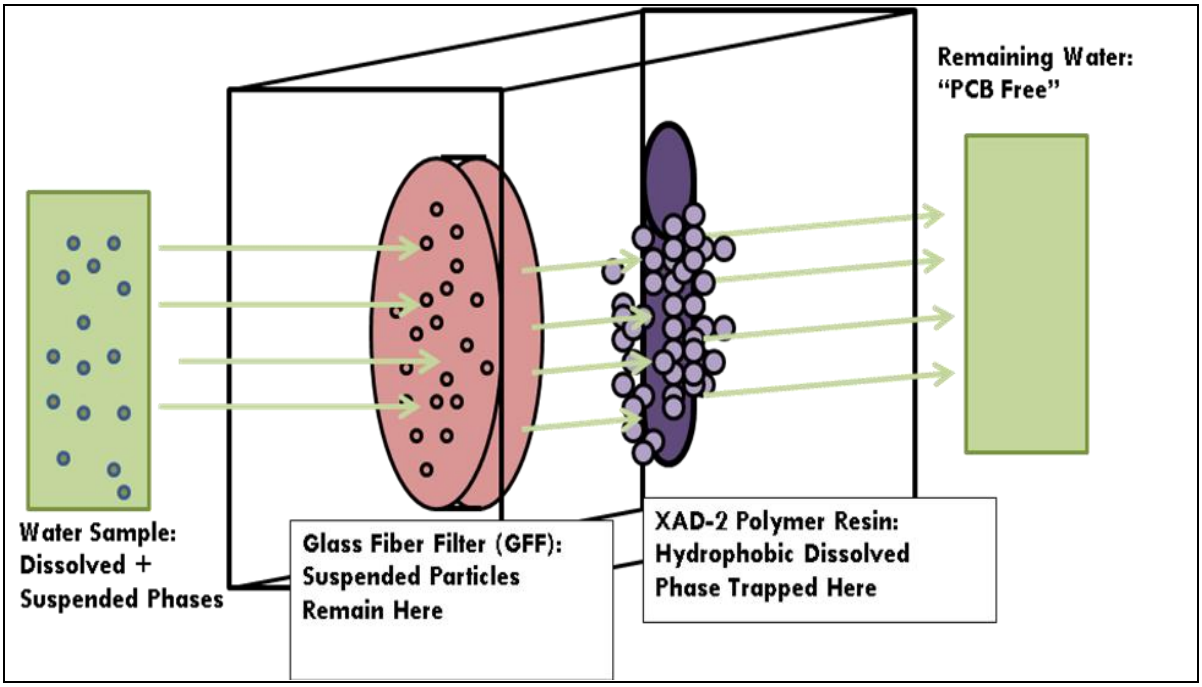

Figure 2.5 Concept of using high volume samplers for PCB concentration

Water sampling was conducted at three different depths (2 ft from bottom, middle, and 1ft from top) as per the guidelines set forth in the project QAPP. A pumping rate of 1.1 ± 0.1 L/min was selected so that a target volume of 200 L was attained in approximately 3 hours. A total of 37 locations in the main channel have been sampled to determine PCB levels in water (dissolved and suspended). Figure 2.1 shows the locations of the stations sampled for water during Summer-Spring 2008, and Table 2.3 includes a description of the sampled sites. In addition to collecting the glass filter and XAD2 resin at each location, water samples composited by depth as specified in the QAPP were collected for TSS, DOC, TPH, and POC analyses. The water for these parameters was not collected using the high volume pump. Instead, a peristaltic

pump was continuously raised and lowered with the high volume pumping line throughout the pumping time. The result was a water sample that was approximately from the same location and at the same time as the high volume sample. Field probe parameters (i.e., pH, temperature, conductivity, and salinity) at the three sampling depths, if applicable, were also obtained using a YSI sonde (YSI 600-XLM). These field probe parameters were taken 1-3 times during each 3-hour sampling.

There were several water sampling locations provided for in the original QAPP that were non-specific. These locations were listed according to a general location or a general purpose because their location needed to be selected in the field. Those locations and an explanation for their choosing are given in Table 2.4 and shown in Figure 2.1.

Table 2.3 Summary station listing of water, sediment, and tissue sampling in Spring-Summer 2008

Segment	Site description	Station ID	Samples to be collected as per QAPP			Samples collected during Spring-Summer 2008				
						Water		Sediment sample date	Fish sample date	
			Water	Sediment	Fish	Sample date	Volume (L)		Catfish	Speckled trout /Atlantic croaker
1007	Sims Bayou at Telephone Rd (USGS 08075500)	11132	x	x	x	5/13/2008[R]	191.0	06/04/08	06/04/08	
1007	Brays Bayou at South Main St.	11139	x			05/13/08	181.5			
1007	Vince Bayou at W. Ellaine St. (USGS 08075730)	11171	x			04/24/08	194.4			
1001	San Jacinto River Tidal IH 10 Bridge East of Channelview	11193	x	x	x	05/01/08	217.2	5/2/2008 (Dup)	05/02/08	08/13/08
1005	Houston Ship Channel at CM 91, Morgan's Point	11252	x	x	x	05/28/08	216.4	05/27/08	05/29/08	08/12/08
1005	Houston Ship Channel at CM 120	11258	x	x	x	06/02/08	202.6	6/2/2008 (Dup)	5/30/2008 (Dup)	06/03/08
1005	Houston Ship Channel San Jacinto River at Lynchburg Ferry	11261	x	x	x	06/04/08	200.4	06/04/08	06/01/08	08/15/08
1005	HSC Between Lynchburg Ferry and IH-10, 121m S AND 1.27km W of Lynchburg Rd and Lakeview Dr	11262	x	x	x	6/4/2008 (Dup)	196.2/213.4 (Dup)	06/04/08	06/04/08	06/04/08
1006	Houston Ship Channel at at San Jacinto Park, West of Battleship Texas	11264	x	x	x	05/01/08	259.6	05/01/08	05/01/08	05/01/08
1006	Houston Ship Channel at CM 150	11270	x	x	x	04/29/08	196.9	04/29/08	04/29/08	04/29/08
1006	Greens Bayou Tidal at Mechling Barge Lines. Alternatively, Greens Bayou at ISK Biosciences Ditch (station 16981)	11274	x	x	x	04/29/08	207.6	04/28/08	04/29/08	
1007	Houston Ship Channel/Buffalo Bayou at Armco Steel Corporation Intake Screens	11280	x	x	x	04/23/08	229.8	04/30/08	04/22/08	08/15/08
1007	Houston Ship Channel/Buffalo Bayou at Confluence with Sims Bayou	11287	x	x	x	04/21/08	204.0	04/28/08	04/22/08	
1007	Houston Ship Channel/Buffalo Bayou in middle of Turning Basin	11292	x	x	x	06/02/08	205.2	06/02/08	06/03/08	
1007	Buffalo Bayou Tidal at Main St.	11347	x	x	x	05/21/08	214.9	06/02/08	06/03/08	

Table 2.3 Summary station listing of water, sediment, and tissue sampling in Spring-Summer 2008

Segment	Site description	Station ID	Samples to be collected as per QAPP			Samples collected during Spring-Summer 2008				
			Water	Sediment	Fish	Water		Sediment sample date	Fish sample date	
						Sample date	Volume (L)		Catfish	Speckled trout /Atlantic croaker
1006	Greens Bayou at Brock Park	11368	x			05/14/08	204.4			
1007	Whiteoak Bayou at Heights Blvd	11387	x			05/12/08	200.5			
1005	Tabbs Bay Midway Between Goose Creek and Upper Hog Island	13338	x	x	x	4/22/2008 (Dup)	204.7/199.1 (Dup)	04/24/08	04/29/08	04/29/08
1005	Black Duck Bay at Mid-Bay	13340	x			06/03/08	200.1			
1005	Scott Bay at Mid-Bay	13342	x	x	x	05/30/08	206.0	06/04/08	05/30/08	08/12/08
1005	Burnett Bay at Mid-Bay	13344	x	x	x	6/3/2008 (Dup)	203.81/203 (Dup)	06/02/08	06/03/08	08/13/08
1005	Barbours Cut mid-way between mouth And terminus	13355	x	x	x	05/29/08	207.0	05/29/08	05/30/08	06/04/08
2421	Bayport Channel mid-way between mouth and terminus	13363	x	x	x	6/11/2008 (Dup)	217.6/212.6 (Dup)	05/27/08	5/28/2008 (Dup)	05/28/08
2421	Upper Galveston Bay at HSC Marker 75	14560	x	x	x	05/28/08	215.3	05/27/08	05/28/08	5/28/2008 (Dup)
1005	Old River Tidal/HSC at Old River Ship Building, Near Lakeside Dr and N Shore Dr	15301	x	x	x	06/04/08	207.9	6/2/2008 (Dup)	06/03/08	08/14/08
1006	HSC at OxyChem Ditch (005/004)	15936	x			04/30/08	213.3		4/30/2008 (Dup)	08/15/08
1006	Houston Ship Channel at Shell Barge Cut, 0.9 mi. downstream of Beltway 8	15979	x	x	x	04/30/08	206.0	04/30/08	4/30/2008	
2421	Upper Galveston Bay at 97GB019, 5.25mi north of the HL&P P. H. Robinson Outfall	16213	x	x	x	05/27/08	204.3	05/27/08	05/28/08	05/28/08
1005	San Jacinto Bay 200 yds SW of CM25 (98GB007)	16499	x	x	x	05/29/08	203.8	05/27/08	05/29/08	08/15/08
1005	Houston Ship Channel/San Jacinto River West of Exxon Docks and North of Alexander Island	16618	x	x	x	05/30/08	217.1	05/29/08	05/29/08	05/29/08

Table 2.3 Summary station listing of water, sediment, and tissue sampling in Spring-Summer 2008

Segment	Site description	Station ID	Samples to be collected as per QAPP			Samples collected during Spring-Summer 2008				
			Water	Sediment	Fish	Water		Sediment sample date	Fish sample date	
						Sample date	Volume (L)		Catfish	Speckled trout /Atlantic croaker
1001	San Jacinto River Tidal at Banana Bend Road at end of pavement in Houston	16622	x	x	x	05/02/08	199.0	05/01/08	05/01/08	
1007	Small ditch discharging to Hunting Bayou	16657	x			06/20/08	202.2			
1006	Patrick Bayou Upstream of Tidal Rd	17149	x			07/29/08	201.3			
1006	Patrick Bayou Shell C001	17157	x			NYS	NYS			
2421	Cedar Bayou at Highway 146	TBD2	x			05/15/08	210.3			
1007	2 Miles Downstream of Shepherd and Buffalo Bayou Near Eleanor Tinsley Park	TBD5	x			05/12/08	181.9			
1007	Hunting at Wallisville Rd	TBD6	x			05/14/08	210.4			
1006	Carpenters at Wallisville Rd	TBD7	x			05/15/08	216.3			
1007	Houston Ship Channel 0.5 miles downstream of Sims Bayou	C001		x				07/12/08		
1007	Houston Ship Channel 0.25 miles upstream of Panther Creek	C002		x				07/12/08		
1007	Houston Ship Channel 500 feet downstream of confluence with Vince Bayou	C003		x				07/12/08		
1007	Houston Ship Channel 1500 feet upstream of Cotton Patch Bayou Tidal	C004		x				07/12/08 (Transect)		
1007	Houston Ship Channel 0.25 miles downstream of Hunting Bayou	C005		x				07/12/08		
1007	Houston Ship Channel 0.5 miles upstream of confluence with Green Bayou	C006		x				07/13/08		
1006	Houston Ship Channel 0.25 miles downstream of confluence with Greens Bayou	E001		x				07/08/08		
1006	Houston Ship Channel 1 mile downstream of confluence with Greens Bayou	E002		x				07/08/08		

Table 2.3 Summary station listing of water, sediment, and tissue sampling in Spring-Summer 2008

Segment	Site description	Station ID	Samples to be collected as per QAPP			Samples collected during Spring-Summer 2008				
						Water		Sediment sample date	Fish sample date	
			Water	Sediment	Fish	Sample date	Volume (L)		Catfish	Speckled trout /Atlantic croaker
1006	Houston Ship Channel 0.45 miles upstream of Beltway 8	E003		x				07/08/08		
1006	Houston Ship Channel immediately east of Beltway 8	E004		x				07/08/08		
1006	Houston Ship Channel 2000 feet upstream of Shell Barge Cut	E005		x				07/08/08		
1006	Houston Ship Channel 870 feet downstream of Shell Barge Cut	E006		x				07/09/08		
1006	Houston Ship Channel 0.67 miles upstream from Patrick Bayou	E007		x				07/09/08		
1006	Houston Ship Channel at Cargill Terminal North of Tidal Road	E008		x				07/09/08		
1006	Houston Ship Channel 900 feet downstream of Patrick Bayou Confluence	E009		x				07/09/08		
1006	Houston Ship Channel midway between Patrick and Tuckers Bayou	E010		x				07/09/08		
1006	Houston Ship Channel 630 feet upstream of Tuckers Bayou	E011		x				07/09/08 (Dup)		
1006	Houston Ship Channel 0.25 miles downstream of Tuckers Bayou	E012		x				07/13/08		
1006	Houston Ship Channel 1600 feet upstream of Carpenters Bayou	E013		x				07/13/08 (Transect, Dup x2)		
1006	Houston Ship Channel 1600 feet upstream of Old River	E014		x				07/13/08		
1006	Houston Ship Channel at the confluence with the San Jacinto River	E015		x				07/13/08		
1007	Brays Bayou just downstream of Wayside	T001		x				07/10/08 (Dup)		

Table 2.3 Summary station listing of water, sediment, and tissue sampling in Spring-Summer 2008

Segment	Site description	Station ID	Samples to be collected as per QAPP			Samples collected during Spring-Summer 2008				
			Water	Sediment	Fish	Water		Sediment sample date	Fish sample date	
						Sample date	Volume (L)		Catfish	Speckled trout /Atlantic croaker
1007	Brays Bayou 830 feet downstream of Lawndale	T002		x				07/10/08		
1007	Brays Bayou 0.35 miles downstream of 75th St	T003		x				07/11/08		
1007	Brays Bayou 840 feet upstream of confluence with Houston Ship Channel	T004		x				07/11/08		
1007	Sims Bayou 0.25 miles upstream of I-45	T005		x				07/10/08		
1007	Sims Bayou just upstream of confluence with Berry Bayou	T006		x				07/10/08		
1007	Sims Bayou 200 feet downstream of Lawndale	T007		x				07/10/08		
1007	Sims Bayou 500 feet upstream of confluence with Houston Shipe Channel	T008		x				07/10/08		
1006	Greens Bayou just upstream of I-10	T009		x				07/13/08 (Dup)		
1006	Greens Bayou 0.82 miles downstream of Market St	T010		x				07/13/08		
1006	Greens Bayou 1.2 miles upstream of Houston Ship Channel	T011		x				07/13/08		
1006	Greens Bayou 0.3 miles upstream of Houston Ship Channel	T012		x				07/13/08		
1007	Vince Bayou 650 feet upstream of South Shaver	T013		x				07/15/08		
1007	Vince Bayou 400 feet upstream of Harris	T014		x				07/15/08 (Dup)		
1007	Vince Bayou 165 feet upstream of confluence with Little Vince Bayou	T015		x				07/15/08		
1007	Vince Bayou 390 feet downstream of confluence with Little Vince Bayou	T016		x				07/15/08		
1007	Buffalo Bayou just upstream of US HWY 59	W001		x				07/11/08		

Table 2.3 Summary station listing of water, sediment, and tissue sampling in Spring-Summer 2008

Segment	Site description	Station ID	Samples to be collected as per QAPP			Samples collected during Spring-Summer 2008				
			Water	Sediment	Fish	Water		Sediment sample date	Fish sample date	
						Sample date	Volume (L)		Catfish	Speckled trout /Atlantic croaker
1007	0.1 miles upstream of Hirsch Road on Buffalo Bayou	W002		x				07/11/08		
1007	Buffalo Bayou 0.5 miles downstream of Lockwood Dr	W003		x				07/11/08		
1007	Buffalo Bayou approximately 1.3 miles upstream of the Turning Basin	W004		x				07/11/08		
1007	Buffalo Bayou ~800 feet downstream of the east edge of the Turning Basin	W005		x				07/11/08		
1007	Houston Ship Channel 0.5 miles upstream of confluence with Brays Bayou	W006		x				07/11/08		
1007	Houston Ship Channel 0.25 miles downstream of I-610	W007		x				07/11/08 (Transect)		
1007	Houston Ship Channel 0.5 miles upstream of confluence with Sims Bayou	W008		x				07/12/08		

Notes:

1) x indicates the matrices that were planned for sampling as per the QAPP.
2) Dup indicates duplicate collected on the same sampling day as the parent.
3) Transect indicates that the sediment sample had a width composited set of samples taken there as well as set of 5 transect samples.
4) Filter from 13363 was not sealed properly and so was re-sampled with a duplicate. The sample date of the rejected sample was 5/27/2008.
5) Trout and Croaker were caught at Site 14560 and will be analyzed for both species.
6) R-Recovery column sample taken. (XAD2 only).
7) TBD indicates a To Be Determined station.
8) NYS indicates Not Yet Sampled.
9) Station 15936, HSC at Oxychem ditch, was sampled for both fish and water.

Table 2.4 Station location changes during sampling

Original QAPP Station ID	Station ID Used	Original QAPP Description	New Field Description	Reason for Selection/Departure	Latitude[a]	Longitude[a]
TBD-1	16657	Small Ditch Discharging to Hunting Bayou	Small WW fed tributary to Hunting Bayou at Ralston Road	This site had easy access and was already a SWQM station. Also, the team should be able to use the PCB concentration here as a stream "background" number by which to isolate the effects of runoff when runoff is sampled from this location.	29.7755	-95.2325
TBD-2	11115	Cedar Bayou Non-Tidal	Cedar Bayou at Highway 146	All that was required for this site was that it was somewhere on Cedar Bayou in a non-tidal section. Due to access difficulties, the site that was chosen was at 1.5 parts per thousand (ppt) salinity, which is greater than the 0.5 ppt threshold normally required for a station to be non-tidal. The site was sampled very near the bridge, and then it was later realized that 11115 is indistinguishably close to the location.	29.77	-94.9161
11351	TBD-5	Buffalo Bayou Tidal At Shepherd Drive In Houston	2 Miles Downstream of Shepherd and Buffalo Bayou Near Eleanor Tinsley Park	This site had easier access than 11351, and the salinity here was 0.12 ppt making it a non-tidal site.	29.7623	-95.3796
11129	TBD-6	Hunting Bayou at North Loop East/IH 610 in Houston	Hunting Bayou at Wallisville Rd	11129 required dropping the sample line down >5 ft straight down a shear drop. It was easier to sample at Wallisvilled Rd.	29.7949	-95.24529
11175	TBD-7	Carpenters Bayou immediately upstream of St Loop 8 near of IH 10 East of Cloverleaf	Carpenter's Bayou at Wallisville Rd	The salinity was definitively non-tidal here (0.23 ppt), and there was good access.	29.8099	-95.1587

[a]The coordinate reference datum for stations TBD-2,5,6,and 7 is NAD83. These coordinates were determined from field descriptions compared to aerial photo locations on ArcGIS. TBD-1 (16657) has coordinates identical to what is found in the SWQM database.

Some problems were encountered during sampling. These include:

1) During the course of shipping, it was found that the 1 μm filter from station 13363 (Bayport channel) was not properly sealed and may have been contaminated with ice in the coolers and water inside the bag. Thus, the sample was rejected and another sample was obtained. Corrective measures where implemented and samples were double bagged thereafter.
2) The micropump portion of all pumps has been replaced due to problems at times with ineffective or inefficient flow. However the sample quality should not be affected by the poor pump performance.
3) Station 17157 (Patrick Bayou Shell C001) was not sampled in Spring-Summer 2008 due to access limitations. Access has been granted by Shell and this sample will be collected at a later date.
4) The QAPP describes the depth composite sample procedure as follows, "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." It was not practical to switch the depth every 30 minutes. Instead it was switched every hour, and the same three-depth compositing was achieved.
5) Originally ambient water samples that were used for TSS, DOC, POC, and TPH measurements were originally collected in large Erlenmeyer flasks. This method was proven to be impractical, inefficient, and unsafe because the flask broke during one of the sampling trips. While the sample was not lost, sample collection thereafter was undertaken using stainless steel canisters sealed by stainless steel lids.

2.1.2 Sediment Sampling

A total of 25 locations have been sampled for sediment in the main channel, San Jacinto River, Upper Galveston Bay, and side bays during the Spring 2008 event (Figure 2.2). Table 2.3 includes a summary of the stations sampled for sediments.

A total of 45 locations (W-001 to 008, C-001 to 006, E-001 to 015, and T-001 to 016) were sampled as part of a detailed sediment sampling effort. The effort was designed to better delineate the location of sediment PCB hot spots in the 1006-1007 region of the HSC (based on sediment sampling data from 2002-2003), to understand the possible sediment transport processes from the tributaries to the Main Channel, and to facilitate anticipated sediment transport modeling in critical areas of the HSC. The samples were gathered using the sediment collection procedures included in the approved QAPP, and were analyzed for the same parameters (PCB congeners, TOC, TPH, Grain Size, and Moisture Content). The sediment intensive effort was conducted in July 2008, and the sampling procedure was slightly different from the Spring 2008 sediment samples in that rather than the 3-5 grabs normally allowed for a sample, nearly every sample had five full grabs[3]. The increase in grabs was instituted to ensure that every sample would be representative of what has historically been a high variability between grabs and grab locations. In addition to normal width-composited sediment samples, transect samples were also collected. Each transect consisted of 5 samples (each sample consisting of 5 grabs at one location within the channel width for a total of 25 grabs per transect) analyzed individually according to the standard set of sediment parameters. The transect samples were placed at evenly spaced intervals, and locations of each sample were recorded according to

[3] The exception to the five full grabs was in narrower sections of Buffalo Bayou or in tributaries (Vince, Sims, Greens, and Brays Bayous) where 3 or 4 grabs provided an adequate spacing across the channel width.

their placement along the channel width. Figure 2.3 shows the intensive sediment sampling locations.

There were no particular field issues or concerns associated with sediment sampling during the sampling events of Spring-Summer 2008.

2.1.3 Tissue Sampling

Tissue was sampled along with the sediment samples (except for sediment intensive locations) to obtain data on bioaccumulation, transport, and ultimately the immediate health risk of PCBs. Species that were sampled include Hardhead Catfish (*Arius felis*), Blue Catfish (*Ictalurus furcatus*), Channel Catfish (*Ictalurus punctatus),* Speckled Seatrout (*Cynoscion nebulosus*), and Atlantic Croaker (*Micropogonias undulates*). The three catfish species were considered as one species group while the trout and croaker made up a second species group. The goal was to get at least one sample at each location with a second sample being from a different species group than the first[4].

For fish tissue collection, gill nets were used with bait (shrimp) to catch enough fish (catfish, trout, croaker) to obtain the appropriate mass of skinless muscle tissue (target mass 100 g or greater). Fish with a total length of 300 mm or greater were the target length for collection. After each station's fish collection, fish were placed into a labeled Ziploc plastic bag and put into a cooler with ice. Once all fish samples were collected, the samples were taken to the UH laboratory, measured, weighed, and processed. Collected fish were filleted with a clean stainless steel knife, packed in clean aluminum foil with the dull side facing the tissue, and placed into

[4] The priority of species collection (in decreasing order) was Speckled Seatrout, Sand Seatrout (none caught in this round of sampling), Atlantic Croaker, Hardhead Catfish, Blue Catfish, and Channel Catfish.

individual Ziploc bags. Fillets were taken from the left side of the fish and, in most cases, the right side was used as a duplicate sample. All Ziploc bags were labeled and frozen until shipment was made to the analytical laboratory. The fish tissue samples of a single species collected at a station were composited into a single sample for analysis. Data recorded during processing included species, length, weight, and gender for each fish in the composited sample.

Fish tissue from 25 locations as outlined in the QAPP has been collected during the Spring-Summer 2008 as part of the assessment of current levels and trends. This information is provided in Table 2.3, along with sample site descriptions. Figure 2.4 depicts the locations of the sites sampled for tissue.

The issues to be considered with respect to fish sampling were:

1) All the sampling locations as specified in the QAPP have been sampled for catfish (designated by F1), while the trout/croaker (designated by F2) were not caught on the sampling day in some locations. The species priority was inclined towards trout/croaker rather than catfish. It is, however, far easier to catch catfish in the HSC and Upper Galveston Bay as opposed to trout/croaker. The sampling team, after examining the species count of the Spring 2008 catch, embarked on a second round of fish sampling at 10 sites in August 2008. These sites, chosen according to their likelihood of catching seatrout, yielded a sample of croaker at 9 out of 10 sites. The final site did not yield a useable sample in either species.
2) Both trout and croaker (F2 samples) were caught at Site 14560 and both species will be analyzed separately. The results are expected to help in bioaccumulation differentiation within trout and croaker species.

3. QUALITY ASSURANCE/QUALITY CONTROL

The quality assurance/quality control (QA/QC) tasks that were conducted included monitoring/coordinating sample deliveries to the laboratories, verifying laboratory compliance with the QAPP, and verification of data packages. There were no major noncompliant issues encountered in the shipping and receiving of the samples collected except for one sample (water for station 13363). All samples were received from the sample site to the UH lab and from the UH lab to analytical laboratories without incident and were within the temperature range specified in the QAPP. The water samples (filter and trap) collected on site 13363 for PCB analysis on 5/27/2008 was found to be contaminated with ice water and so had to be resampled.

Once the sample results were obtained from the labs, the results were reviewed by UH/Parsons personnel using QA/QC criteria specified in the QAPP. The QA/QC requirements outlined in the QAPP include: holding times, method blanks, initial calibration curves, ambient water reporting limits (AWRL) verification, laboratory control sample (LCS), field duplicates, matrix spikes/matrix spike duplicates, laboratory duplicates, continuing calibration samples, surrogates, and internal standards. As of this writing, not all results have been received back from the laboratories. Table 3.1 lists the data received to date.

The data received from the laboratories has been reviewed and verified. Table 3.2 shows the data flags that were used to designate the data as needed based on the QA/QC review.

Table 3.1 Percentage of sample results obtained and reviewed for QAQC

Laboratory	Media	Analysis	Number of samples collected	Number of sample results obtained from lab*	Number of sample results reviewed for QAQC¶	% Results reviewed for QAQC¶
Xenco	Water	TPH, TSS, DOC	44	44	42	95.5%
Xenco/PTS	Sediment	TPH, Grain size and Solids content	100	100	99	99.0%
Maxxam	Water	POC	40	40	0	0%
Maxxam	Water	PCB (209 Congeners)	91	86	77	84.6%
Maxxam	Sediment	PCB (209 Congeners), TOC	100	30	17	17.0%
Maxxam	Fish	PCB (209 Congeners), Lipid and Moisture content	53	12	12	22.6%

¶Results obtained from lab were reviewed for QAQC criteria by UH/Parsons personnel

* Number of sample results received as of 9/12/2008

Table 3.2 Standardized flags assigned to sample results

Flag	Description
B	Blank contamination (result is less than twenty times the amount found in the associated blank).
U	Target analyte is not detected above the method detection level (MDL) in the sample.
J	Result is between the method detection limit (MDL) and the reporting level (RL) or the value is to be considered an estimate due to quality control issues involved in the analysis.
H	Holding time exceedance
I	Ion ratio failure
F	Field duplicate exceedance (%RPD of parent/duplicate sample > 50%)
L	Lab duplicate exceedance (%RPD of lab/lab duplicate sample > 50%)
S	Blank spike or lab control spike exceedance
Q	Limit of Quantitation (LOQ) exceedance
D	Surrogate/Internal Standard exceedance
R	Sample result is to be rejected and is considered unusable.

3.1 QA/QC for Water Samples

3.1.1 TSS, TPH, and DOC

The following summary is for the 42 samples for which the QAQC has been completed.

- The TSS analyses were performed using EPA Method 160.2. All samples were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples were prepared and analyzed within the holding times (7 days) required by the method with the exception of samples listed below in Table 3.3. The holding time exceedances above are considered minor, although the TSS results were flagged "H" as estimated.

- The DOC analyses were performed using EPA Method SM5310. All samples were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples were prepared and analyzed within the holding times as required by the method.
- The TPH analyses were performed using Texas 1005. All samples were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples were prepared and analyzed within the holding times required by the method. The hydrocarbons analyzed for by this method include: C6-C12 (Gasoline), C12-C28 (Diesel) and C28-C35 (Oil) Range Hydrocarbons.

Table 3.3 Holding time exceedance of water samples analyzed for TSS

Sample ID	Collection date	Flag applied	Time exceeded (days)
11287-W-1	4/21/2008	H	2.89
13338-W-1-DUP	4/22/2008	H	1.87
13338-W-1	4/22/2008	H	1.93
11387-W-1	5/12/2008	H	1.09
15301-W-1	6/4/2008	H	1.30
11262-W-1	6/4/2008	H	1.30
11262-W-1-DUP	6/4/2008	H	1.30
11261-W-1	6/4/2008	H	1.30
TRIP2-W-1	6/4/2008	H	1.30

3.1.1.1 Bias (Accuracy)

Bias is a statistical measurement of correctness and includes components of systematic error. A measurement is considered unbiased when the value reported does not differ from the true value. Accuracy was evaluated using the percent recovery (%R) results for the blank spike

samples (BS) and/or Blank Spike Duplicate (BSD) samples in the case of TSS and TPH analysis. The BS/BSD %Rs were within method acceptance criteria for all data packages. In the case of DOC analysis, accuracy was evaluated using the %R results for the blank spike samples (BS) and the matrix spike (MS) and/or matrix spike duplicate (MSD) samples. The BS %Rs were within method acceptance criteria for all data packages. The MS and MSD %Rs were within method acceptance criteria for all Sample Delivery Groups (SDGs), except for one data package. The MSD for DOC was not analyzed due to insufficient sample volume. No corrective action was required with respect to bias since the blank spike and MS passed the %R for that batch. Table 3.4 gives the summary statistics of the bias calculated from each data package. All the data packages were within QAPP requirements.

Table 3.4 Accuracy of water sample results for DOC, TPH and TSS analyses

	DOC (Water)	**TPH (Water)**	**TSS (Water)**
QAPP Bias Requirement (%)	80 - 120	70 - 135	80 - 120
Min Bias (%)	92.40	81.00	95.35
Max Bias (%)	103.00	123.00	107.00
Average Bias (%)	96.90	97.60	100.03
95% Confidence level of mean (%)	94.44 - 99.36	87.56 - 107.65	97.18 - 102.89

3.1.1.2 Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from either of the parent sample/field duplicate sample results, lab duplicate results, BS/BSD and/or MS/MSD results.

Each TSS batch QC included a BS and BSD samples and all BS/BSD % RPDs were within QAPP required tolerance. Each TPH batch QC included a BS and BSD; however

precision was not calculated since all TPH results were below the reporting limit. Each DOC batch QC included a BS, MS and MSD and all % RPDs in general were within QAPP required tolerance, except for one data package when the MSD for DOC was not analyzed due to insufficient sample volume. However the lab duplicate samples complied with the required QAPP %RPD and so precision was acceptable for that batch.

Table 3.5 Precision of water sample results for DOC, TPH and TSS analyses

	DOC (Water)	TPH (Water)	TSS (Water)
QAPP Precision Requirement	20	25	20
Min Precision	1.10	0.66	0.00
Max Precision	14.58	12.90	5.10
Average Precision	5.53	4.11	1.21
95% Confidence level of mean	2.5 - 8.55	1.63 - 6.59	0.2 - 2.23

3.1.1.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the chain-of-custody procedures to those described in the QAPP
- Evaluating holding times
- Examining method blanks for contamination of samples during analysis

The samples in the data package were collected and analyzed following the QAPP, COC procedures, and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis with the exception of few TSS samples. An “H” flag was applied to the TSS results that exceeded the holding time.

There was at least one method blank analyzed with each batch associated with the TSS,DOC, and TPH analyses in each data package. The method blanks were in all cases below the RLs. As required by QAPP, trip blanks were sent to the lab. The summary of trip blank results for TSS, DOC, and TPH analyses are summarized in Table 3.6. As can be seen from the table, the TSS and TPH results for both trip blanks were less than the reporting limit. However in the case of DOC, one trip blank was a non-detect while another had a DOC of 2.62 mg/L. It is not yet clear whether the DOC contamination occurred at the site or in the analytical lab. This issue is still being considered and corrective measures will be undertaken to ascertain the cause of the relatively high DOC in the trip blank.

Table 3.6 DOC, TSS and TPH results for trip blanks

	DOC (mg/L)	TSS (mg/L)	Total TPH (mg/L)
TRIP1-W-1	<1.00	<5.00	<5.00
TRIP2-W-1	2.62	<5.00	<5.00

3.1.1.4 Completeness

Completeness was evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data. No reported results for samples have been rejected or invalidated (qualified "R"). The completeness of the data results obtained from lab and reviewed for QAQC is 100% compared to the minimum acceptance limit of 90%.

3.1.1.5 Field and Lab Duplicates

A field duplicate is defined as a split sample (or measurement) from the same location, collected in immediate succession (after homogenization), using identical techniques. The following samples were collected and analyzed for field duplicate QC purposes: 13338-W-1 (sampled on 4/22/08), 13344-W-1 (sampled on 6/3/08), 13363A-W-1 (sampled on 6/11/08), and 11262-W-1 (sampled on 6/4/08). Field duplicates were collected at a frequency of 10.3 %, well above the frequency required as per QAPP (5%). Table 3.7 below summarizes the relative percent deviation of the field duplicates (FRPD) for TSS, DOC, and TPH samples collected. As can be observed, the average FRPDs for TSS, DOC, and TPH were 17%, 5%, and NC respectively. All field duplicate results were within QAPP tolerance.

In addition to field duplicates, samples were also analyzed in duplicate for lab QC purposes. All lab duplicate results were within QAPP tolerance. No lab duplicates were conducted in the case of TPH due to extraction processes involved in analysis. Lab duplicates were collected at a frequency of 18.6 % or higher in the case of TSS and DOC analysis, well above the frequency required as per QAPP (5%).

Table 3.7 Relative Percent Deviation of the Field Duplicates

Sample ID	RPD[a] (%)		
	DOC	TPH	TSS
13338-W-1	11.59	NC	36.58
13344-W-1	5.71	NC	5.41
13363A-W-1	0.53	NC	8.00
11262-W-1	1.56	NC	16.09

[a]Field duplicate RPD required as per QAPP is 50% or lower.
NC: Not Calculated due to non detect in samples

3.1.2 Polychlorinated Biphenyls

The data submitted by the laboratory has been reviewed and verified following the guidelines outlined in the QAPP and National Functional Guidelines for Organic and Inorganic Data. Information reviewed in the data packages include sample results; the laboratory quality control results; instrument calibrations; blanks; case narrative and chain-of-custody forms. The verification protocol addressed the following parameters: method blanks, laboratory control spike recoveries, recoveries of labeled compounds (internal standards), continuing calibration verifications, laboratory and field duplicate sample percent reproducibility (%RPD), percent recovery (%R), and Level of Quantification (LOQ) standard results.

All samples were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples collected were prepared and analyzed for PCB congeners within the holding times required by the method. Several water samples required dilution due to high PCBs and/or matrix interference. As shown in Table 3.1, 86 out of 91 samples have been analyzed and results reported by the lab, while 77 sample results have been reviewed for QAQC by UH/Parsons. Table 3.8 summarizes the data package and the samples in each data package for which QAQC has been completed.

Table 3.8 QAQC completed water samples for PCB analysis

Data package #	Trap samples	Filter samples	Sample collection date
A844238	11287-D-1-Trap	11287-SU-1- Filter	4/21/08
	13338-D-1-Trap	13338-SU-1- Filter	4/22/08
	13338-D-1-Dup-Trap	13338-SU-1-Dup- Filter	4/22/08
	11280-D-1-Trap	11280-SU-1- Filter	4/23/08
	11171-D-1-Trap	11171-SU-1- Filter	4/24/08
	11270-D-1-Trap	11270-SU-1- Filter	4/29/08
	11274-D-1-Trap	11274-SU-1- Filter	4/29/08
	15936-D-1-Trap	15936-SU-1- Filter	4/30/08
	15979-D-1-Trap	15979-SU-1- Filter	4/30/08
A845831	11264-D-1- Trap	11264-SU-1- Filter	5/1/08
	11193-D-1- Trap	11193-SU-1- Filter	5/1/08
	16622-D-1- Trap	16622-SU-1- Filter	5/2/08
A852960	11387-D-1- Trap	11387-SU-1- Filter	5/12/08
	TBD5-D-1- Trap	TBD5-SU-1- Filter	5/12/08
	11132-D-1- Trap	11132-SU-1- Filter	5/13/08
	11368-D-1- Trap	11368-SU-1- Filter	5/14/08
	TBD6-D-1- Trap	TBD6-SU-1- Filter	5/14/08
	TBD2-D-1- Trap	TBD2-SU-1- Filter	5/15/08
	TBD7-D-1- Trap	TBD7-SU-1- Filter	5/15/08
	11347-D-1- Trap	11347-SU-1- Filter	5/21/08
	11132-D-1-REC- Trap		5/13/08
	11139-D-1- Trap		5/13/08
A858269	16618-D-1- Trap	16618-SU-1- Filter	5/30/08
	13342-D-1- Trap	13342-SU-1- Filter	5/30/08
	11292-D-1- Trap	11292-SU-1- Filter	6/2/08
	11258-D-1- Trap	11258-SU-1- Filter	6/2/08
	TRIP1-D-1- Trap	TRIP1-SU-1- Filter	6/2/08
	13344-D-1- Trap	13344-SU-1- Filter	6/3/08
	13344-D-1-DUP- Trap	13344-SU-1-DUP- Filter	6/3/08
	13340-D-1- Trap	13340-SU-1- Filter	6/3/08
A855832	16213-D-1- Trap	16213-SU-1- Filter	5/27/08
	11252-D-1-TRAP	11252-SU-1- Filter	5/28/08
	14560-D-1-TRAP	14560-SU-1- Filter	5/28/08

Table 3.8 QAQC completed water samples for PCB analysis

Data package #	Trap samples	Filter samples	Sample collection date
A855832	13355-D-1- Trap	13355-SU-1- Filter	5/29/08
	16499-D-1- Trap	16499-SU-1- Filter	5/29/08
		11139-SU-1- Filter	5/13/08
A863358	13363-D-1- Trap	13363A-SU-1-Filter	6/11/08
	13363-D-1-DUP- Trap	13363A-SU-1-DUP- Filter	6/11/08
	ERB1-D-1- Trap	ERB1-SU-1- Filter	6/11/08
	ERB2-D-1- Trap	ERB2-SU-1- Filter	6/11/08

3.1.2.1 Accuracy

Accuracy was evaluated using the percent recovery (%R) results for the blank spike samples (BS), Limit of Quantification (LOQ) samples, and labeled compound spikes. The BS, LOQ and labeled compound spike recoveries %Rs were within method acceptance criteria, except for the congeners summarized in Table 3.9. For one batch (SDG A855832), the lab failed to analyze an LOQ-Filter. Since the extraction and analyses process for traps and filters are very closely related, the LOQ-Trap recoveries were used to determine the acceptability for the filter samples in this same batch. The "NC" in the table above indicates "Not Calculated" due to the lab having to force the reporting limit of those specific congeners above the spiking level due to the lab's MDL results showing a high standard deviation. Since these LOQ recoveries could not be calculated or beyond QAPP acceptable limits, all associated congeners that weren't previously flagged "J", "U", or "B" by the lab, were flagged as estimated ("Q") for the samples analyzed in that batch.

Table 3.9 Basis for flagging PCB water results for accuracy

Data package #	Sample	Analyte	% Recovery	% QAPP Bias requirement
A844238	LOQ-Trap	22'DiCB-(4)	NC	65-135
	LOQ-Trap	4,4'-DiCB-(15)	NC	65-135
	LOQ-Filter	22'DiCB-(4)	NC	65-135
	LOQ-Filter	4,4'-DiCB-(15)	NC	65-135
	LOQ-Filter	22'34'55'6-HeptaCB-(187)	160	65-135
A845831	LOQ-Trap	22'DiCB-(4)	NC	65-135
	LOQ-Trap	4,4'-DiCB-(15)	NC	65-135
	LOQ-Trap	HeptaCB-(180)+(193)	52.5	65-135
	LOQ-Filter	22'DiCB-(4)	NC	65-135
	LOQ-Filter	4,4'-DiCB-(15)	NC	65-135
	LOQ-Filter	HeptaCB-(180)+(193)	50.0	65-135
A852960	LOQ-Trap	HeptaCB-(180)+(193)	59.5	65-135
A855832	LOQ-Trap	HeptaCB-(180)+(193)	51.0	65-135
A858269	LOQ-Trap	22'DiCB-(4)	NC	65-135
	LOQ-Trap	4,4'-DiCB-(15)	NC	65-135
	LOQ-Trap	HeptaCB-(180)+(193)	57.5	65-135
	LOQ-Filter	22'DiCB-(4)	NC	65-135
	LOQ-Filter	4,4'-DiCB-(15)	NC	65-135
	LOQ-Filter	HeptaCB-(180)+(193)	57.5	65-135
A863358	LOQ-Trap	22'DiCB-(4)	NC	65-135
	LOQ-Trap	4,4'-DiCB-(15)	NC	65-135
	LOQ-Trap	23'44'5-PentaCB-(118)	165	65-135
	LOQ-Trap	HeptaCB-(180)+(193)	62.5	65-135
	LOQ-Filter	22'DiCB-(4)	NC	65-135
	LOQ-Filter	4,4'-DiCB-(15)	NC	65-135
	LOQ-Filter	HeptaCB-(180)+(193)	55.0	65-135

3.1.2.2 Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the parent sample/field duplicate sample results. The following samples were collected and analyzed

in duplicate for field duplicate QC purposes: 13338-D-1-Trap, 13338-SU-1-Filter, 13344-D-1-Trap, 13344-SU-1-Filter, 13363-D-1-Trap, and 13363-SU-1-Filter. There were several exceedances for % RPD in field duplicates results and both the parent and field duplicate samples were flagged "F" as estimated if the %RPD was out of tolerance limits. All associated congeners, that weren't previously flagged "J", "U" or "B" by the lab, were flagged "F".

3.1.2.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the chain-of-custody procedures to those described in the QAPP
- Evaluating holding times
- Examining method blanks for contamination of samples during analysis.

The samples were collected and analyzed following the QAPP, COC procedures, and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis. All initial calibration criteria, all continuing calibration criteria (BS), and all LOQ standard criteria were met with the exceptions mentioned above. There was at least one method blank analyzed with each batch associated with the PCB analyses in each batch. The method blanks had many PCBs of concern above the RLs and the sample results that were less than five (5) times the amount found in the blank were "B" flagged for having blank contamination.

Trip blanks were also collected as part of the sampling plan and Trip1 results have been obtained. Several congeners were detected in both the trap trip blanks (3 congener detects, and

109 congeners either flagged with J and/or B) and filter trip blanks (8 congener detects, and 89 congeners flagged with J).

3.1.2.4 Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data. No reported results so far have been rejected or invalidated. The completeness of the data results obtained from lab and reviewed for QAQC is 100% compared to the minimum acceptance limit of 90%.

3.2 QA/QC for Sediment Samples

3.2.1 TPH

Since there isn't QC data analysis required for particle size analysis and solids content, data verification was focused on TPH sediment analysis only. The TPH analyses were performed using TPH by Texas 1005. All samples were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples collected over the sampling phase have been reviewed for QAQC except for one trip sample. As shown in Table 3.1, all samples from the first phase and intensive sediment sampling phase have been analyzed and results reported by the lab, while 99 sample results have been reviewed for QAQC by UH/Parsons. All samples were prepared and analyzed within the holding times required by the method, with the exception of sample 16622-SE-1. This sample was analyzed 5.16 days outside of the required 14 day HT and an "H" flag was applied to the sample result. The hydrocarbon ranges analyzed for by this method included C6-C12 (Gasoline), C12-C28 (Diesel) and C28-C35 (Oil) Range Hydrocarbons.

3.2.1.1 Bias (Accuracy)

Accuracy was evaluated using the %R results for the blank spike samples (BS) and MS/MSD recovery results. The BS/MS/MSD %Rs were within method acceptance criteria for all data packages (Table 3.10). All MS/MSD recoveries were within acceptance criteria except for one batch which had a high concentration of C12-C28 in the parent sample. No corrective actions were required since the sample spiked was not from this project.

Table 3.10 Accuracy and precision of sediment sample results for TPH analyses

	Precision	**Bias (%)**
QAPP requirement	25	70-135
Min	1.72	79.00
Max	13.50	92.50
Average	4.58	85.40
95% Confidence level of mean	-1.64 to 10.81	77.46 to 93.34

3.2.1.2 Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the parent sample/field duplicate sample results and the MS/MSD duplicate results. All field duplicate results and MS/MSD % RPD were within acceptance criteria. Each TPH batch QC included a BS/MS/MSD and all % RPDs were within QAPP required tolerance (Table 3.10).

3.2.1.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the chain-of-custody procedures to those described in the QAPP
- Evaluating holding times
- Examining method blanks for contamination of samples during analysis.

The samples were collected and analyzed following the QAPP, COC procedures, and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis except for one sample for which a flag was applied. There was at least one method blank analyzed with each batch associated with the TPH analyses in each SDG. The method and field blanks were below the RLs. Two trip blanks sampled and analyzed for TPH had values less than the reporting limit.

3.2.1.4 Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data. No reported results for TPH samples have been rejected or invalidated. The completeness of the data results obtained from lab and reviewed for QAQC is 100% compared to the minimum acceptance limit of 90%.

3.2.1.5 Field and Lab Duplicates

The following samples were collected and analyzed for TPH for field duplicate QC purposes: 11193-Se-1, 15301-Se-1, T014-Se-1, T009-Se-1, W002-Se-1, E011-Se-1, E013-Se-1-A, E013-Se-1-B, T001-Se-1. Field duplicates were collected at a frequency of 10%. The relative percent deviation of the field duplicates (FRPD) could not be evaluated since all samples were

non detected (ND) for TPH. No lab duplicates were conducted in the case of TPH due to extraction processes involved in analysis.

3.2.2 Polychlorinated Biphenyls and Total Organic Carbon

As shown in Table 3.1, 30 out of 100 samples have been analyzed and results reported by the lab, while 17 sample results has been reviewed for QAQC by UH/Parsons. The partial data from the first phase of sampling (Table 3.11) submitted by the laboratory has been reviewed and verified following the guidelines outlined in the QAPP and National Functional Guidelines for Organic and Inorganic Data. Information reviewed in the data packages include sample results; the laboratory quality control results; instrument calibrations; blanks; case narrative and chain-of-custody forms. The verification protocol addressed the following parameters: method blanks, laboratory control spike recoveries, recoveries of labeled compounds (internal standards), continuing calibration verifications, laboratory and field duplicate sample percent reproducibility (%RPD), percent recovery (%R), and Level of Quantification (LOQ) standard results.

Table 3.11 QA/QC for PCBs in sediment samples

Data package #	Sediment samples	Sample collection date
A845781	13338-Se-1	4/24/2008
	11287-Se-1	4/28/2008
	11274-Se-1	4/28/2008
	11270-Se-1	4/29/2008
	15979-Se-1	4/30/2008
	16622-Se-1	5/1/2008
	11280-Se-1	4/30/2008
	11264-Se-1	5/2/2008
	11193-Se-1-Dup	5/2/2008
	11193-Se-1	5/2/2008
A855832	16213-Se-1	5/27/2008
	11252-Se-1	5/27/2008
	14560-Se-1	5/27/2008
	13363-Se-1	5/27/2008
	16499-Se-1	5/27/2008
	16618-Se-1	5/29/2008
	13355-Se-1	5/29/2008

3.2.2.1 Total Organic Carbon (TOC) in Sediment

The TOC analyses were performed using LECO Combustion. All samples were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples were analyzed within the holding times as required by the method, with the exception of 13338 (collected 4/24/08). Sample 13338, collected on 4/24/08 was analyzed 2 days outside of the holding time and so the sample was flagged "H" for the minor exceedances of holding time for TOC.

3.2.2.1.1 Accuracy and Precision

Accuracy was evaluated using the %R results for the blank spike samples (BS). The BS %Rs were 90% and well within QAPP acceptance criteria (80-120%). Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the lab duplicate results. Each TOC batch QC included a lab duplicate, and % RPDs were zero and within QAPP required tolerance of < 20.

3.2.2.1.2 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the chain-of-custody procedures to those described in the QAPP
- Evaluating holding times
- Examining method blanks for contamination of samples during analysis.

The samples were collected and analyzed following the QAPP, COC procedures, and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis. All initial calibration criteria and continuing calibration criteria (BS) were met. There was at least one method blank analyzed with each batch associated with the TOC analyses and the method blanks were below the RLs. Four trip blanks were collected in total, two for the first phase of sediment sampling and another two for intensive sediment sampling phase. The trip blank results from the first phase of sampling have been obtained, however QAQC is yet to be reviewed. The laboratory followed a reporting limit (LOQ) of 500 mg/Kg instead of 100 mg/Kg

as specified in QAPP, the reason being that the laboratory was not able to meet the low LOQ requirement. No further action was taken because the sample results were well above the LOQ.

3.2.2.1.3 Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data. No reported results for samples in this SDG have been rejected or invalidated. The completeness of the data results obtained from lab and reviewed for QAQC is 100% compared to the minimum acceptance limit of 90%.

3.2.2.1.4 Field and Lab duplicates

The following sample was collected and analyzed in duplicate for field duplicate QC purposes: 11193-SE-1 (collected 5/2/08). The field duplicate result that has been received is within QAPP tolerance. Samples were also analyzed in duplicate for lab duplicate QC purposes and all lab duplicate results were within QAPP tolerance. The frequency of field and lab duplicates that have been collected and results reviewed is 6.3 and 11.8% respectively which are higher than the required frequency (5%).

3.2.2.2 Polychlorinated Biphenyls in Sediment

The PCB analyses were performed using USEPA Method 1668A. All samples were collected and analyzed following the procedures and protocols outlined in the QAPP. All samples were analyzed within the holding times required by the method. Some sediment samples required dilution due to the high PCB concentrations and/or matrix interference.

3.2.2.2.1 Accuracy

Accuracy was evaluated using the %R results for the blank spike samples (BS), Limit of Quantification (LOQ) samples, and labeled compound spikes. The BS, LOQ and labeled compound spike recoveries %Rs were within method acceptance criteria, except for the data package (A855832) which had blank spike recovery (193%) outside the acceptance criteria (50-150%) for a congener group (HexaCB-(156)+(157)). So the following samples in that batch were flagged "S" for the congener listed above due to the out of tolerance BS recovery: 16213, 11252, 14560, 13363, 16499, 16618 and 13355.

3.2.2.2.2 Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the field and lab duplicate sample results. One parent/field duplicate sample has been analyzed. All associated congeners, that weren't previously flagged "J", "U" or "B" by the lab, were flagged as estimated ("F") if the congener was out of precision tolerance limits. Both the parent and field duplicate samples were flagged if the % RPD of parent and sample were beyond the QAPP precision limits. Samples were also analyzed in duplicate for lab duplicate QC purposes and all lab duplicate results were within QAPP tolerance.

3.2.2.2.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the chain-of-custody procedures to those described in the QAPP
- Evaluating holding times

- Examining method blanks for contamination of samples during analysis.

The samples were collected and analyzed following the QAPP, COC procedures, and analytical procedures. All samples were prepared and analyzed within the holding times required for the analysis. All initial calibration criteria were met and all continuing calibration criteria (BS) were met, with the exception of those mentioned above

All LOQ standard criteria were met, and there was at least one method blank analyzed with each batch associated with the PCBs analyses in each data package. The method blanks had many PCBs of concern above the RLs and the sample results that were less than five times the amount found in the blank were flagged "B" for having blank contamination.

3.2.2.2.4 Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data. No reported results for samples in this SDG have been rejected or invalidated. The completeness of the data results obtained from lab and QAQC reviewed is 100% compared to the minimum acceptance limit of 90%.

3.2.2.2.5 Field and Lab duplicates

The following sample was collected and analyzed in duplicate for field duplicate QC purposes: 11193-SE-1 (collected 5/2/08). As mentioned earlier, parent and duplicate sample results were flagged if the congener was not within QAPP tolerance of %RPD <50. Samples were also analyzed in duplicate for lab duplicate QC purposes and all lab duplicate results were

within QAPP tolerance. The frequency of field and lab duplicates for the results reviewed is 6.3 and 5.9% respectively which is higher than the required frequency (5%).

3.3 QA/QC for Fish Samples

3.3.1 Polychlorinated Biphenyls

As shown in Table 3.1, 12 out of 53 samples have been analyzed and results reported by the lab, while 12 sample results have been reviewed for QA/QC by UH/Parsons. The partial data from the first phase of sampling (Table 3.12) submitted by the laboratory has been reviewed and verified following the guidelines outlined in the QAPP and National Functional Guidelines for Organic and Inorganic Data. Information reviewed in the data packages included sample results; the laboratory quality control results; instrument calibrations; method blanks; case narrative and chain-of-custody forms. The verification protocol addressed the following parameters: method blanks, laboratory control spike recoveries, recoveries of labeled compounds (internal standards), continuing calibration verifications, laboratory and field duplicate sample percent reproducibility (%RPD), percent recovery (%R), and Level of Quantification (LOQ) standard results. All samples collected were prepared and analyzed within the holding times required by the method.

Table 3.12 QAQC completed tissue samples for PCB analysis

Data package #	Sediment samples	Sample collection date
A845862	15979-F1-1-TISSUE	4/30/08
	15979-F1-1-DUP-TISSUE	4/30/08
	11264-F1-1-TISSUE	5/1/08
	13338-F1-1-TISSUE	4/29/08
	11274-F1-1-TISSUE	4/29/08
	13338-F2-1-TISSUE	4/30/08
	11264-F2-1-TISSUE	5/1/08
	16622-F1-1-TISSUE	5/1/08
	11270-F2-1-TISSUE	4/29/08
	11270-F1-1-TISSUE	4/29/08
	11280-F1-1-TISSUE	4/22/08
	11287-F1-1-TISSUE	4/22/08

3.3.1.1 Accuracy

Accuracy was evaluated using the percent recovery (%R) results from the blank spike samples (BS), Limit of Quantification (LOQ) samples, and labeled compound spikes. The BS, LOQ Check Standard, and labeled compound spike recoveries %Rs were within method acceptance criteria, except for one congener group (HeptaCB-(180)+(193) which had percent LOQ recovery of 47%, which is out of the tolerance limits (60-140). So all the associated fish samples in that group listed in Table 3.12 were flagged for the congener group due to the out of tolerance LOQ recovery. This congener was flagged "Q" in all samples.

3.3.1.2 Precision

Precision was evaluated using the Relative Percent Difference (%RPD) obtained from the parent/duplicate sample results. The sample (15979-F1-1) was collected and analyzed in duplicate for field duplicate QC purposes. The sample was flagged if the %RPD were not within QAPP tolerance. All associated congeners in the parent and field duplicate samples that weren't previously flagged "J", "B" or "U" by the lab, were flagged as estimated ("F") if %RPD was out of tolerance limits.

3.3.1.3 Representativeness

Representativeness expresses the degree to which sample data accurately and precisely represents actual site conditions. Representativeness has been evaluated by:

- Comparing the chain-of-custody procedures to those described in the QAPP
- Evaluating holding times
- Examining method blanks for contamination of samples during analysis.

The samples were collected and analyzed following the QAPP, COC procedures and analytical procedures. All samples were prepared and analyzed with the holding times required for the analysis. All initial calibration criteria, continuing calibration criteria (BS), and LOQ standard criteria were met. There was at least one method blank analyzed with each batch associated with the PCB analyses in each batch. The method blanks had many PCBs of concern above the RLs and the sample results that were less than five (5) times the amount found in the

blank were “B” flagged for having blank contamination. Three trip blanks were prepared in the all media sampling phase but the results have not been received yet.

3.3.1.4 Completeness

Completeness has been evaluated by comparing the total number of samples collected with the total number of samples with valid analytical data. No reported results for samples in this SDG have been rejected or invalidated. The completeness of the data results obtained from lab and reviewed for QAQC is 100% compared to the minimum acceptance limit of 90%.

4. WATER, SEDIMENT AND TISSUE QUALITY PARAMETER RESULTS

This section provides a summary of the data that has been received to date from the laboratories. The data include field water quality parameters (pH, salinity, conductivity and water temperature), characteristics of water (TSS, TPH, POC and DOC) and sediment samples (TPH, Grain Size, TOC, Moisture Content), and lipid content analysis for tissue samples.

4.1 In-stream Water Quality

Appendix A provides a summary of field parameters measured during in-channel water sampling activities. The pH, salinity, and conductivity averages by station are shown in Figures 4.1, 4.2 and 4.3, respectively. The field parameters summarized by segments, shown in Figure 4.4, are shown in 4.5, 4.6 and 4.7 for pH, salinity, and conductivity respectively. From Figure 4.1 it can be seen that the pH was in the range of 7-8.5, except for station 11171, Vince Bayou at W. Ellaine St, which had a pH value of 9.74 (complete range 9.26 – 10.26). Appendix A for that station indicates total depth of 0.1 foot, so the pH is very likely related to benthic algae at a shallow sunny warm and stagnant water. The pH in that range indicates dense algae -algal productivity which removes CO_2 from water column, affecting natural buffering chemistry and pushing pH high during daylight hours. The pH was also the same regardless of the segment or depth for stations where multiple depths were sampled for pH.

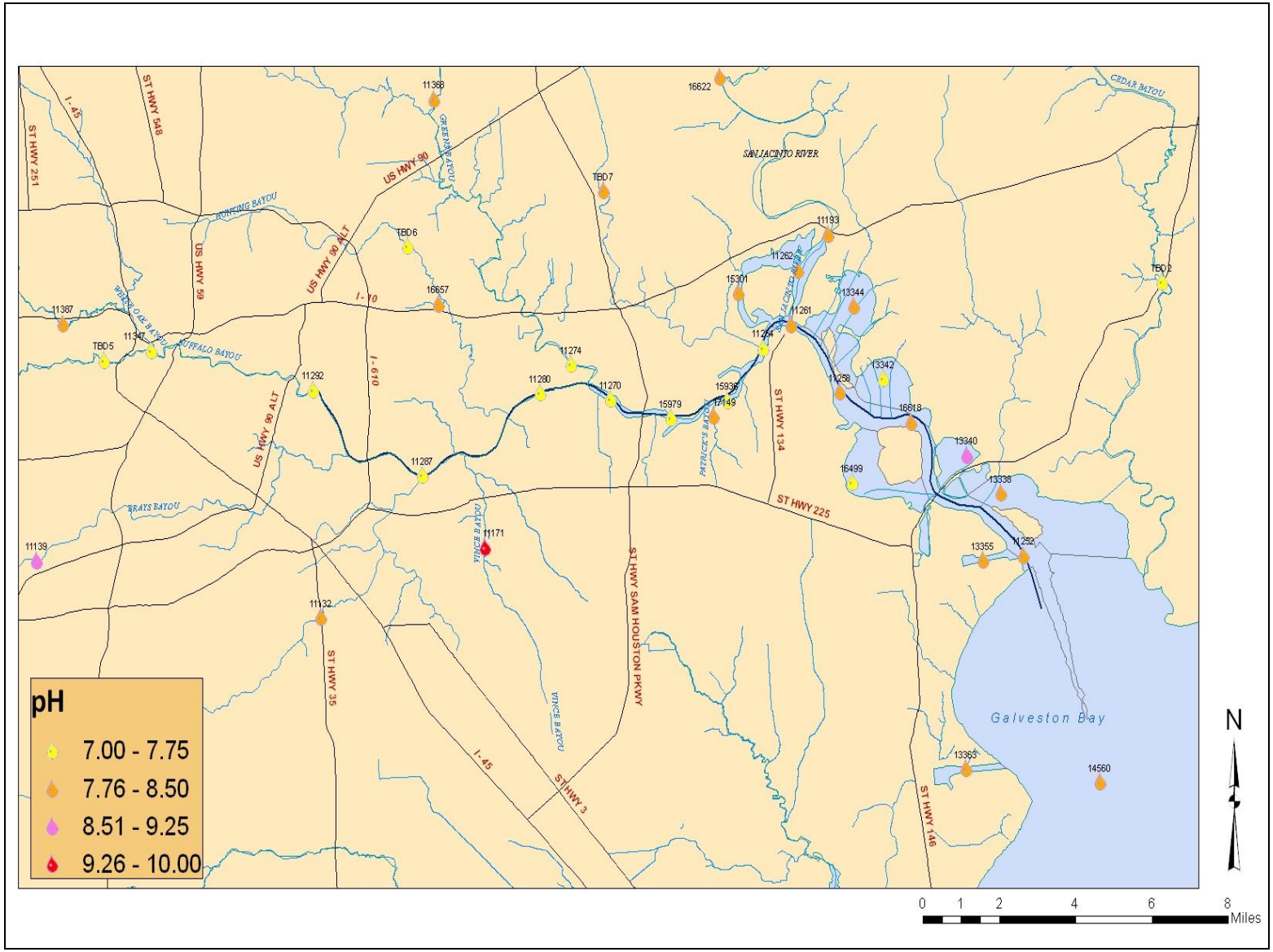

Figure 4.1 Depth and time averaged pH readings for water samples in Spring-Summer 2008 sampling

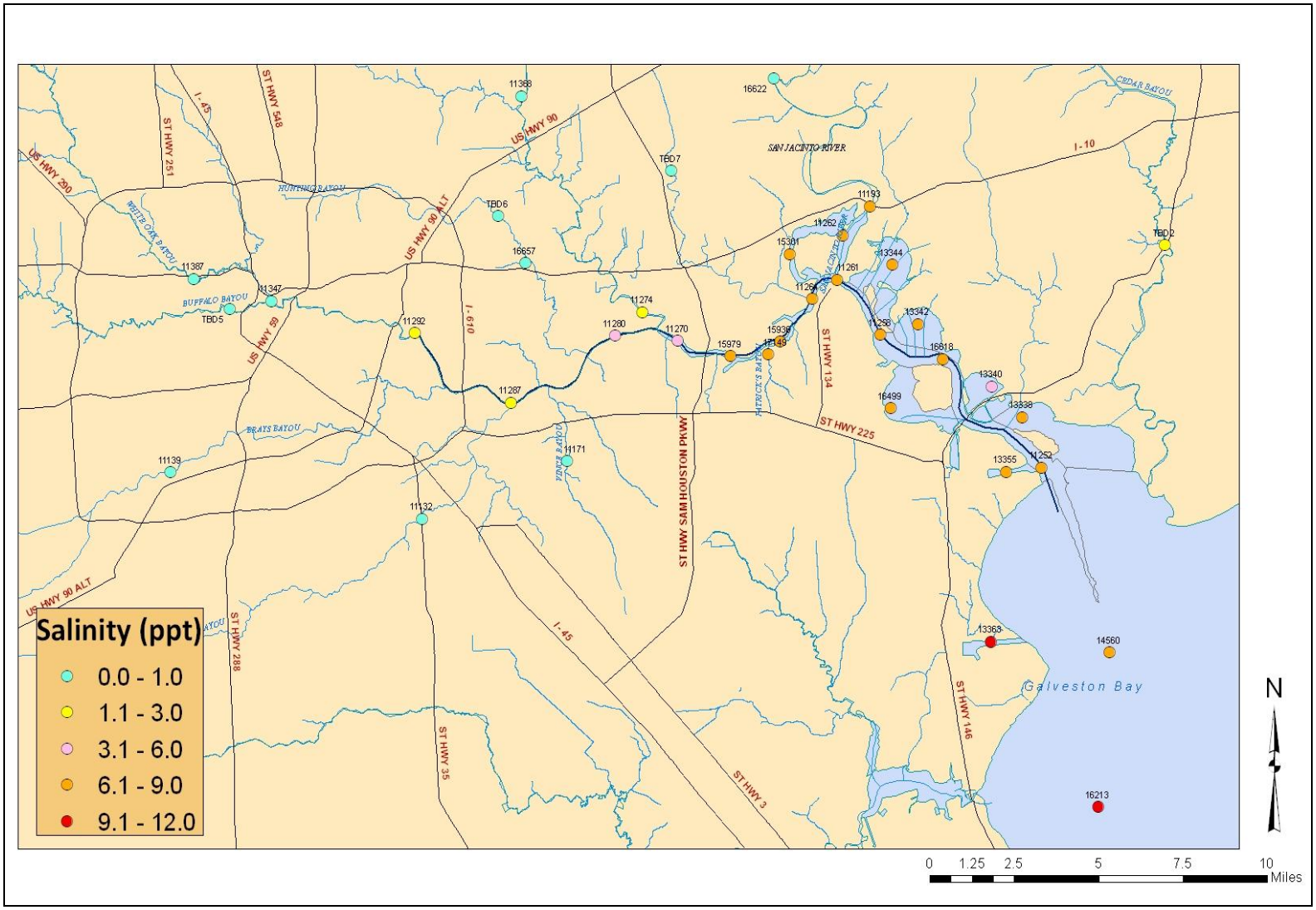

Figure 4.2 Depth and time averaged salinity measurements in part per thousand for the Spring-Summer 2008 water sampling

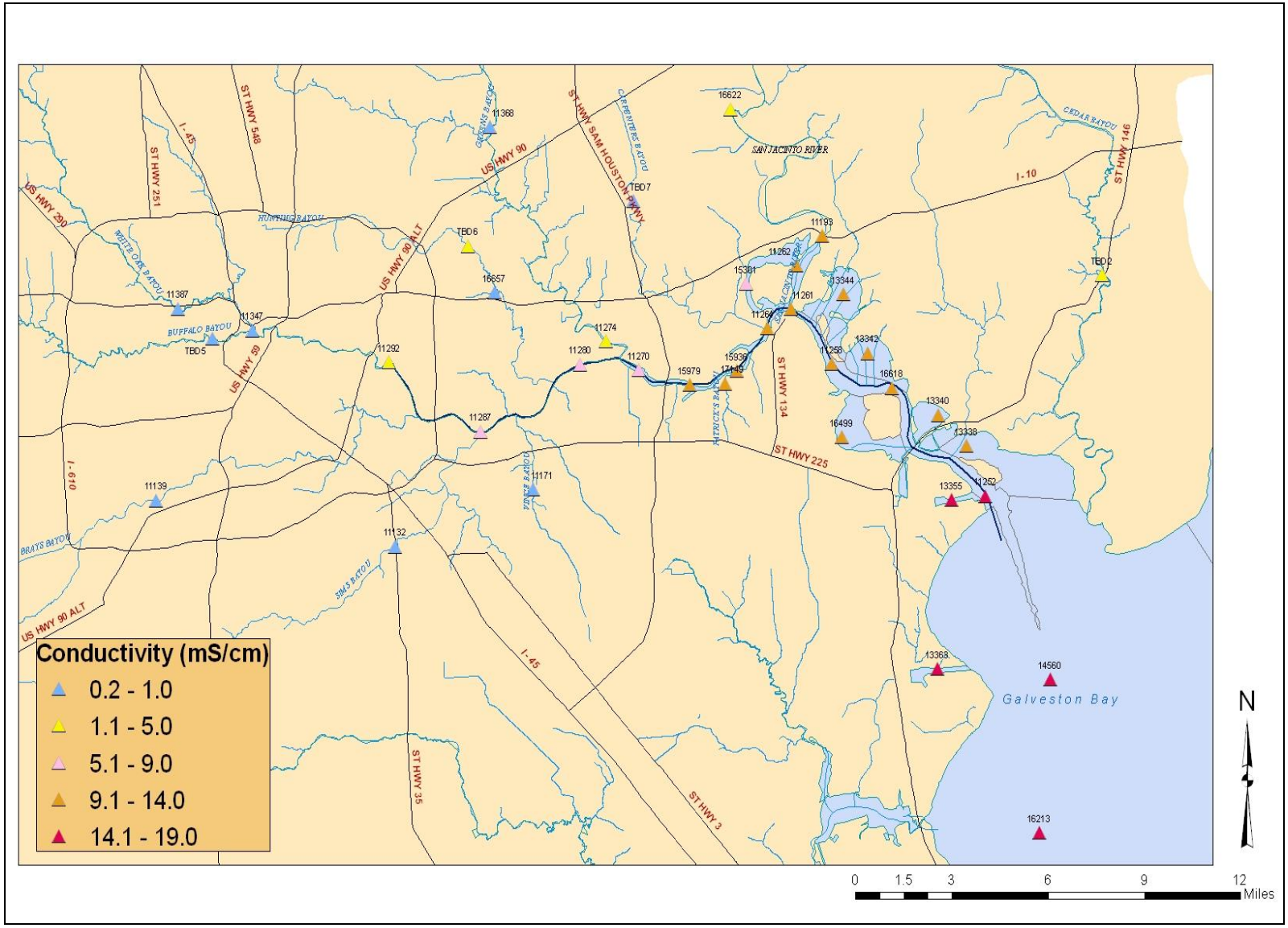

Figure 4.3 Depth and time averaged conductivity measurements from Spring-Summer 2008 water sampling

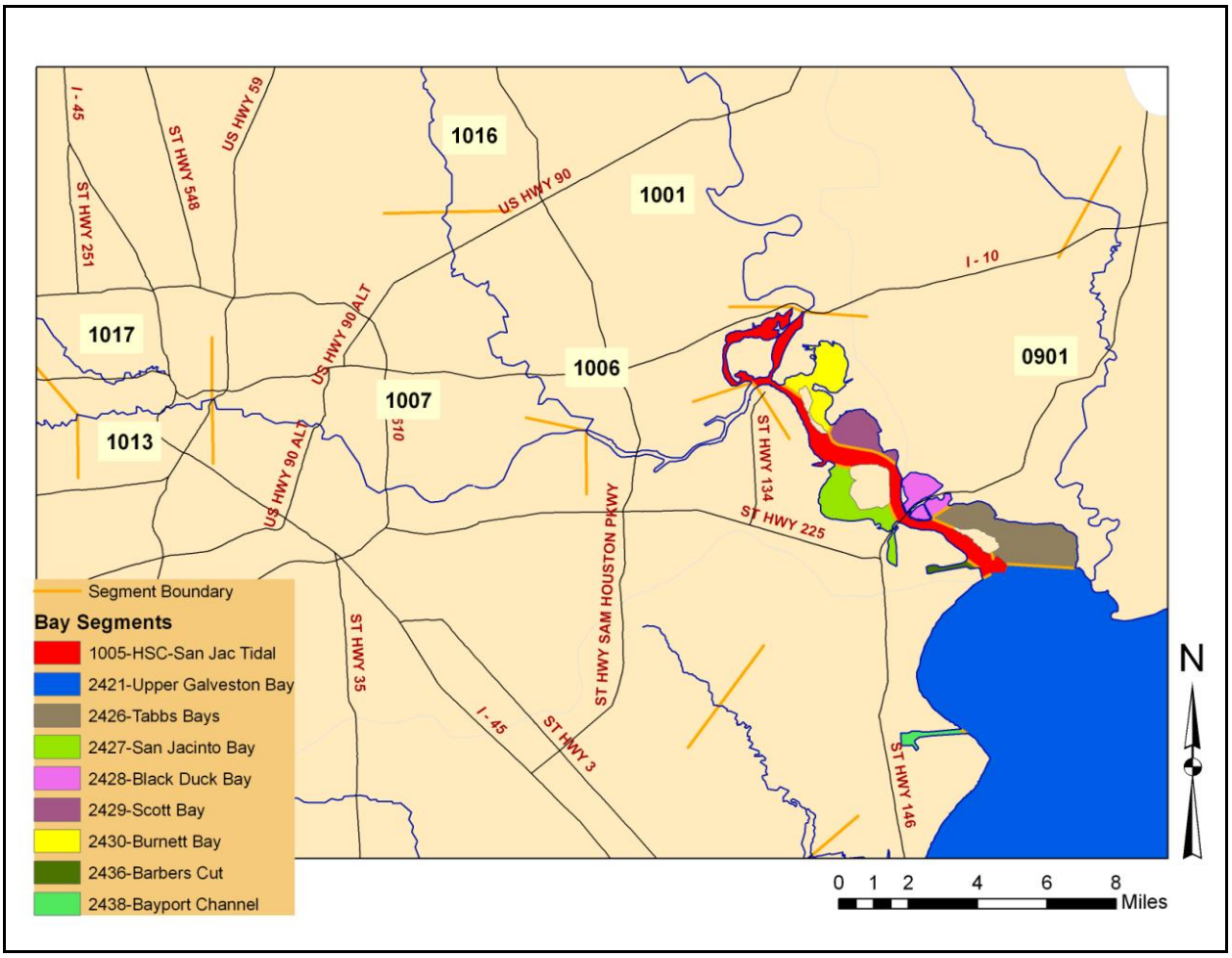

Figure 4.4 Houston Ship Channel water quality segments

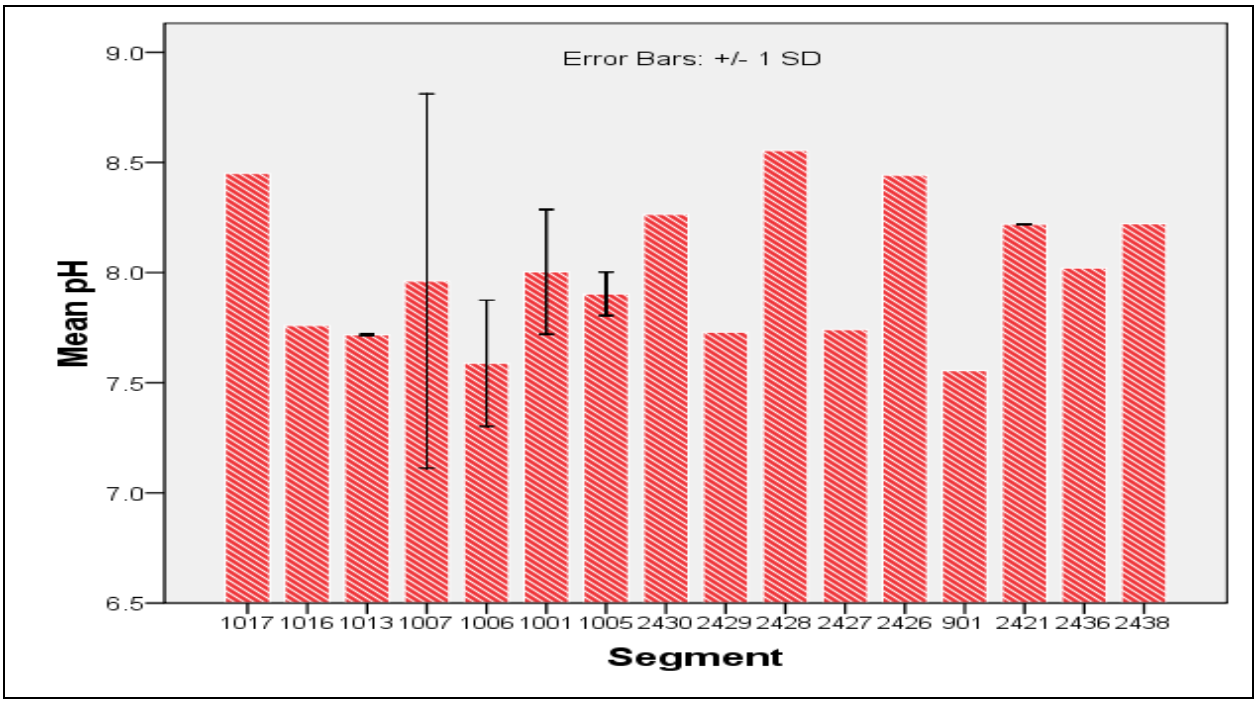

Figure 4.5 Depth and time averaged pH measurements averaged by segment

As expected, the salinity and conductivity were relatively low in the tributaries, while both salinity and conductivity increased with the approach of the channel to Galveston Bay understandably due to tidal influence (Figures 4.2 and 4.3). The increase in salinity can easily be observed from the salinity averages by station and segment shown in Figures 4.2 and 4.5 respectively. There was thermal variation with depth in some stations, and this trend was almost always a decrease in temperature with depth (average temperature slope -0.064˚C/ft). No appreciable and consistent trends were observed though the effect of salt wedge intrusion indicating the presence of salinity stratification was observed in some sites. The conductivity averages shown in Figures 4.3 and 4.7 indicate low conductivity values in fresh waters (tributaries) and an increase in the Main channel due to tidal influence and the influence of salinity. The correlation between salinity and conductivity shown in Figure 4.8 indicates a good linear fit.

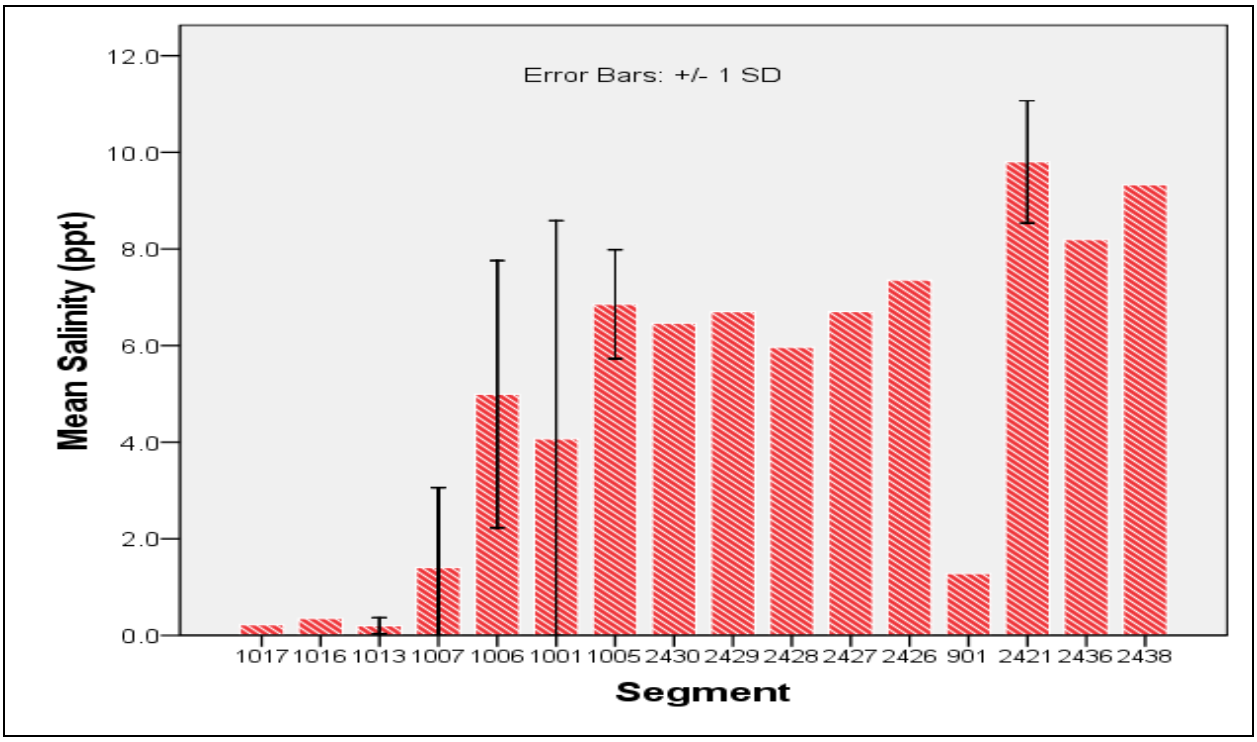

Figure 4.6 Average salinity values per segment in parts per thousand

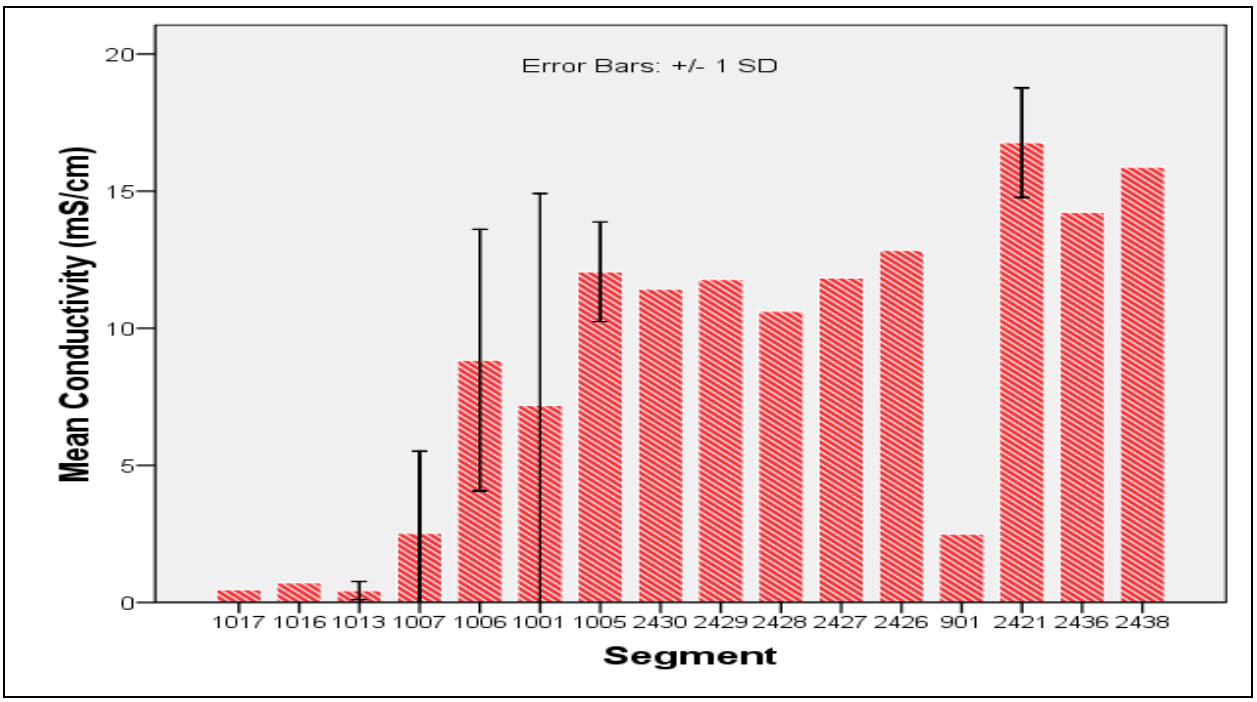

Figure 4.7 Average specific conductivity values per segment in mS/cm

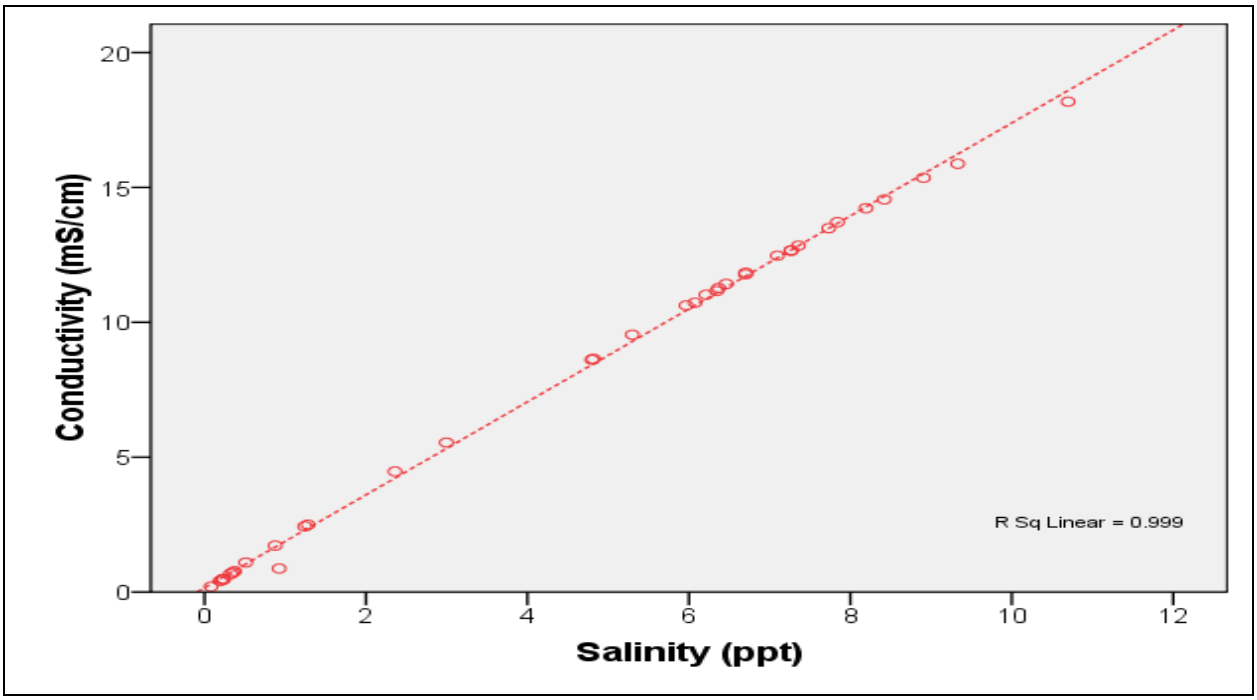

Figure 4.8 Linear regression analysis between conductivity (mS/cm) and salinity (ppt) in water samples collected in Spring-Summer 2008

Other lab based measures of water quality taken were TPH, DOC, and TSS. Table 4.1 summarizes the water quality parameters (TSS, DOC and TPH) by station. Figures 4.9, 4.10, and 4.11 show spatial locations of the TPH, DOC and TSS values, while Figures 4.12, 4.13, and 4.14 show TPH, DOC and TSS values averaged on a segment basis. TPH results were non-detect in every sample except for one at station 11368, Greens Bayou at Brock Park. It was the intent in the sampling design to try and discover if some link existed between TPH concentrations and PCB concentrations. Since nearly all TPH analyses were non-detect, this link (at least in water) either does not exist or exists at lower TPH concentrations than what was tested. DOC has a pattern that appears to be almost opposite of the salinity pattern previously described. The farther out towards the Bay and the less tidal, the lower the DOC. TSS trends generally increase with flow, which is to say that the further downstream the higher the TSS. Tributaries show low TSS

while the main channel increases in TSS especially downstream of Lynchburg Ferry. The exact cause of these results is unknown though it is likely that higher velocities, higher tidal forces, wave action, increased ship traffic, and dredging activities suspend a great amount of sediment in the downstream waters.

Table 4.1 TSS, DOC and TPH measurements by station

Station ID	TSS (mg/L)	DOC (mg/L)	TPH (mg/L)
11132	74	8.75	<5.00
11139	11	6.03	<5.00
11171	<5.00	6.69	<5.00
11193	84	2.54	<5.00
11252	106	1.98	<5.00
11258	70	3.06	<5.00
11261	71	2.55	<5.00
11262[a]	43.5	2.56	<5.00
11264	53	2.49	<5.00
11270	32	3.19	<5.00
11274	40	4.48	<5.00
11280	35	3.16	<5.00
11287	28	5.21	<5.00
11292	22	7.56	<5.00
11347	18	6.31	<5.00
11368	24	7.96	13.67
11387	18	6.47	<5.00
13338[a]	128.5	2.07	<5.00
13340	102	3.38	<5.00
13342	89	3.23	<5.00
13344[a]	74	3.33	<5.00
13355	95	1.83	<5.00
13363[a]	50	1.88	<5.00
14560	81	1.59	<5.00
15301	50	3.01	<5.00
15936	22	2.73	<5.00
15979	21	2.62	<5.00
16213	144	1.41	<5.00

Table 4.1 TSS, DOC and TPH measurements by station

Station ID	TSS (mg/L)	DOC (mg/L)	TPH (mg/L)
16499	83	2.27	<5.00
16618	92	2.96	<5.00
16622	24	9.31	<5.00
16657	4	7.75	<5.00
17149	90	2.06	<5.00
TBD2	37	7.9	<5.00
TBD5	39	5.41	<5.00
TBD6	20	6.22	<5.00
TBD7	94	7.94	<5.00

a Average of duplicate samples, otherwise concentration of a single sample

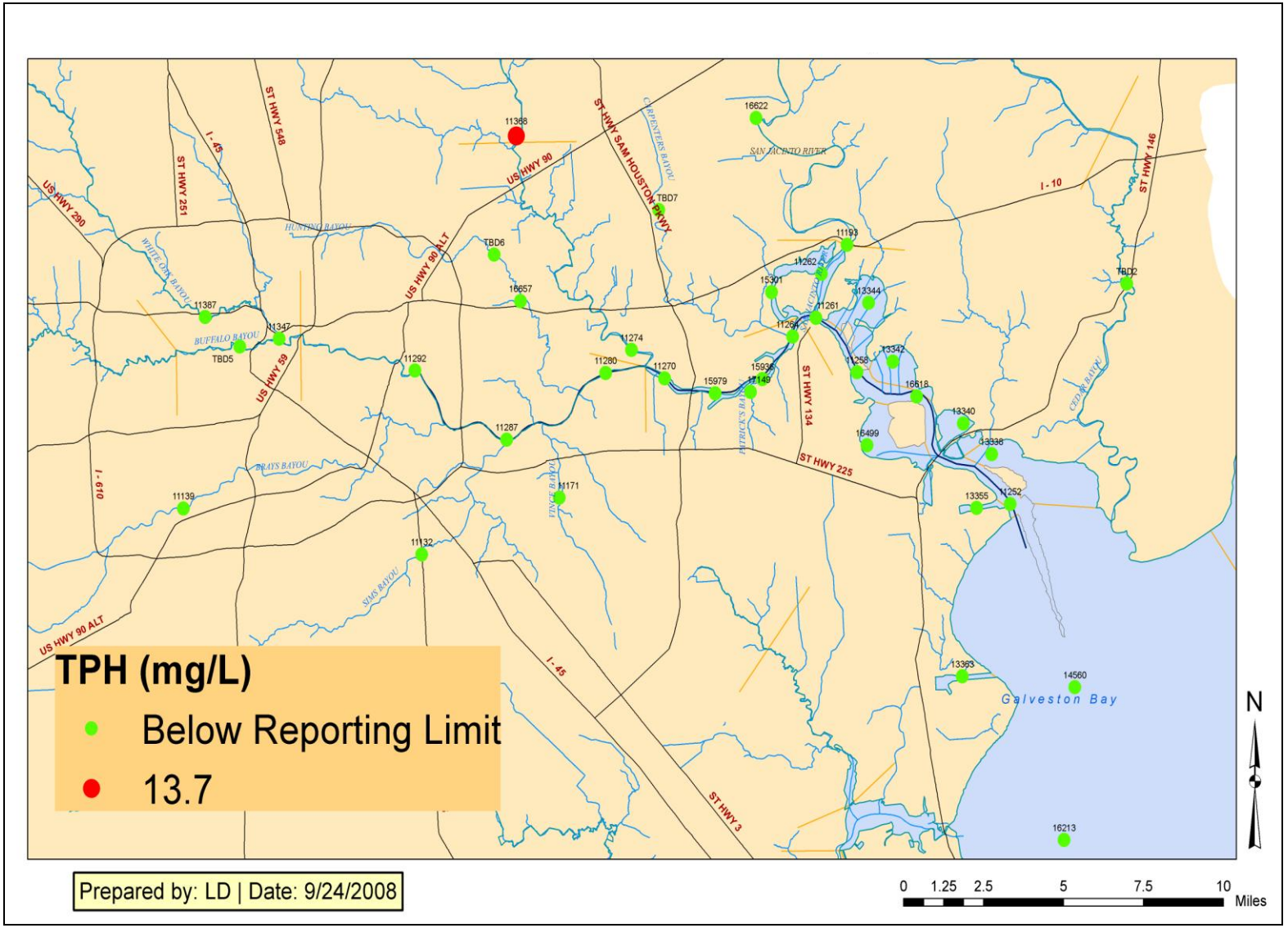

Figure 4.9 Total TPH measurements for Spring-Summer 2008 water samples

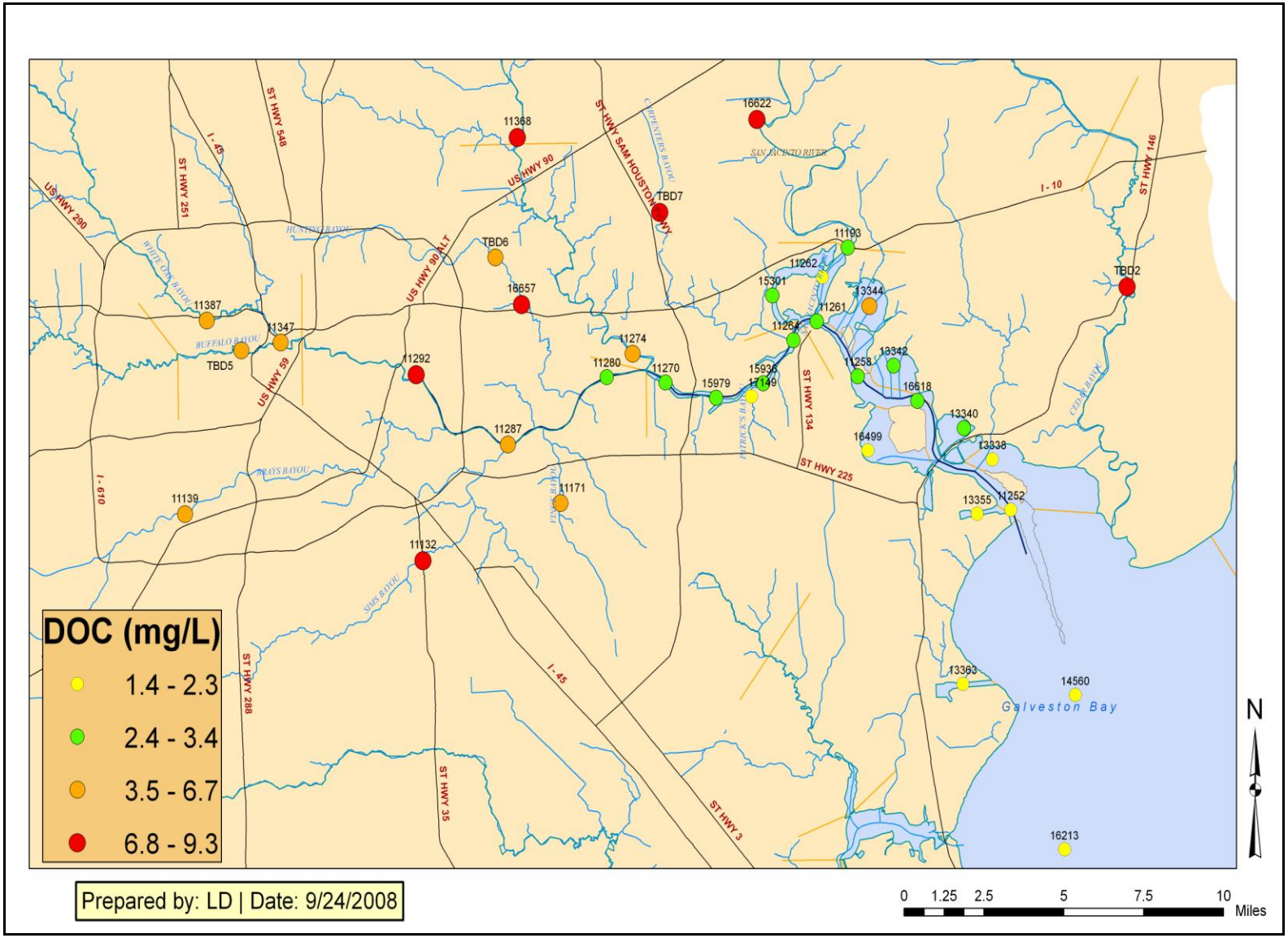

Figure 4.10 DOC measurement in water samples collected in Spring-Summer 2008

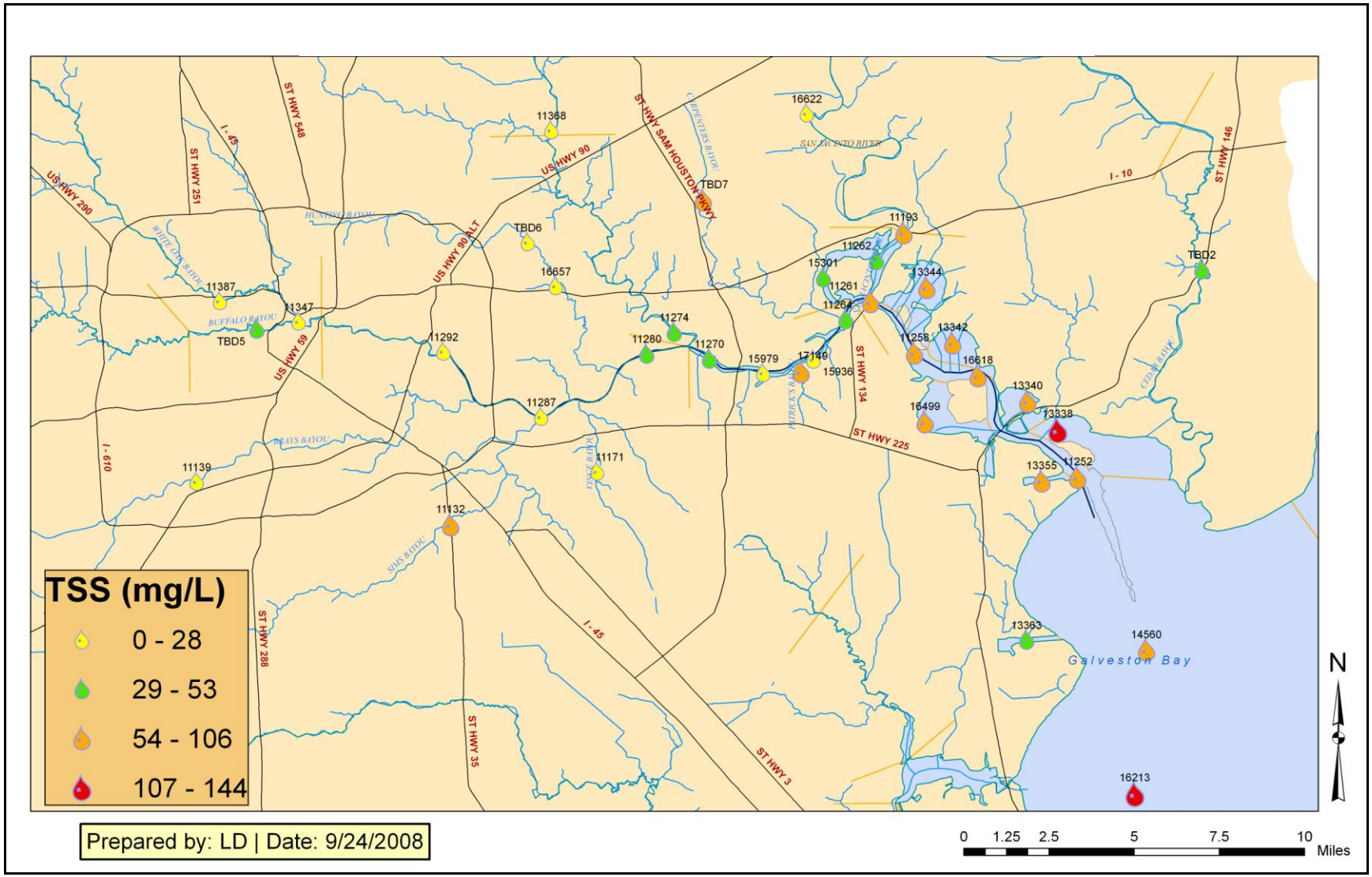

Figure 4.11 TSS measurements in water samples collected in Spring-Summer 2008

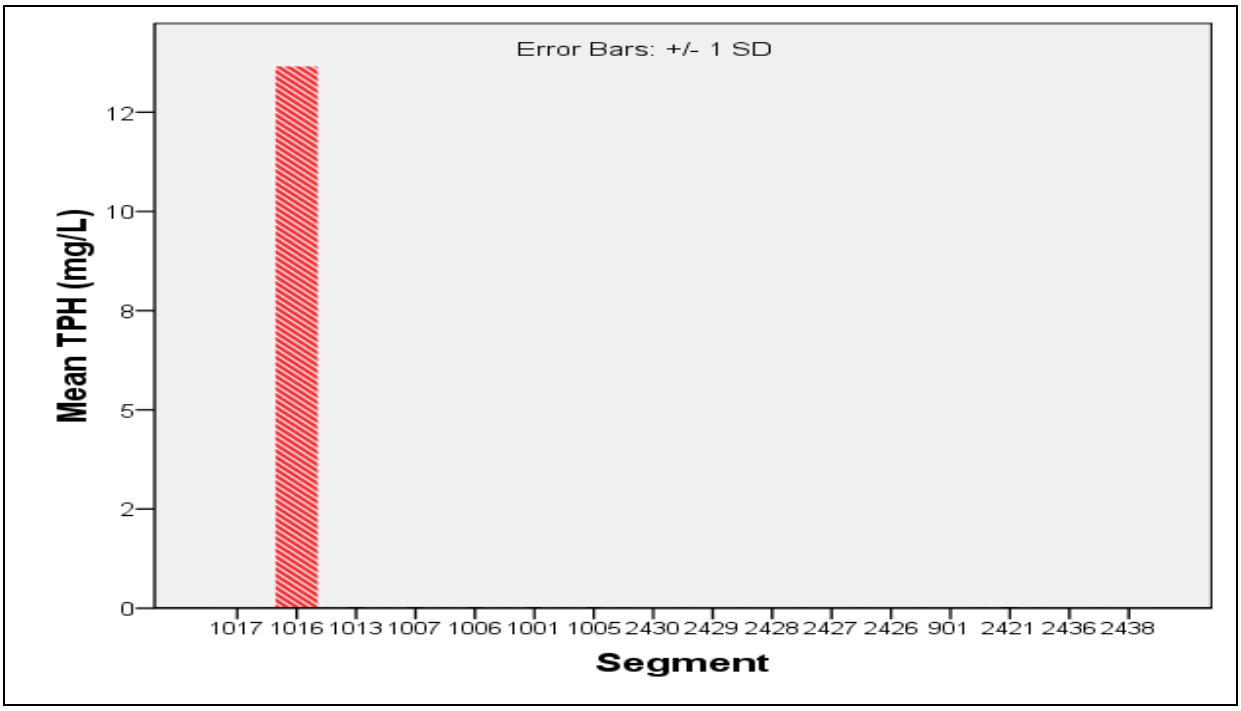

Figure 4.12 Average total TPH values per segment in water

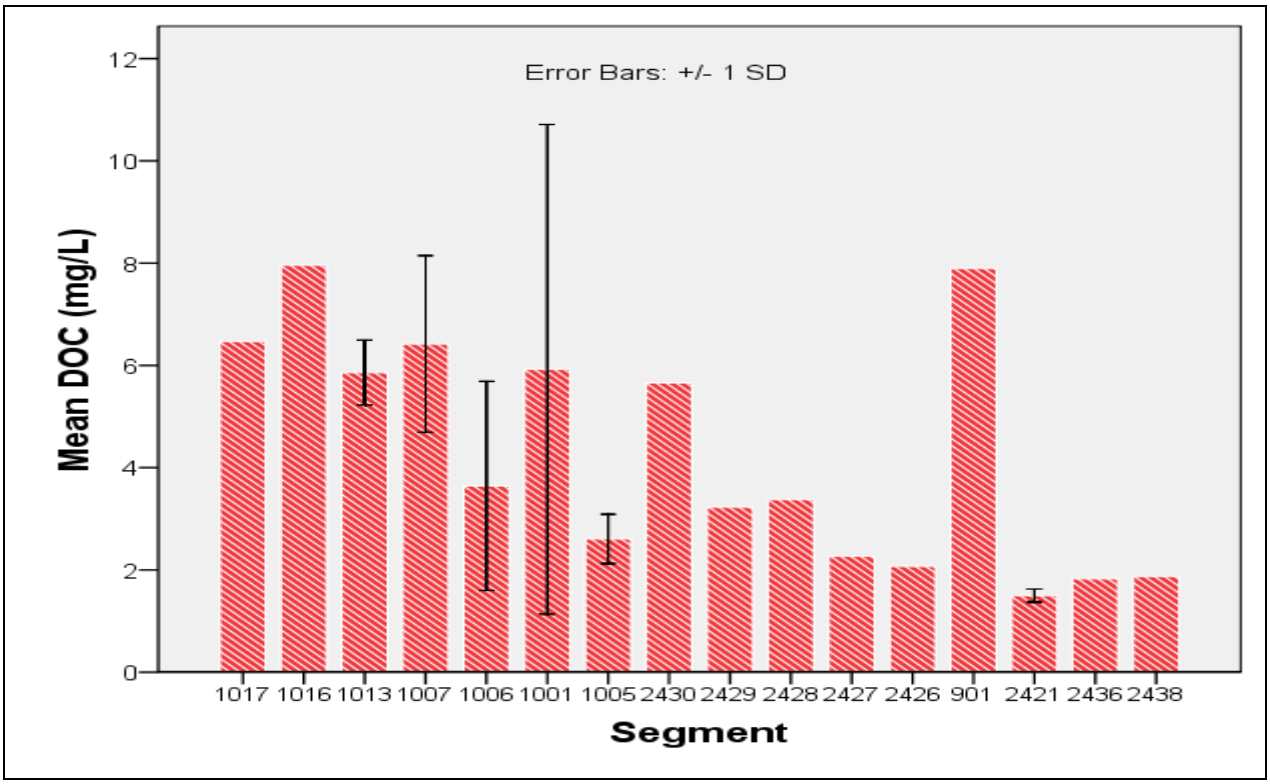

Figure 4.13 Average DOC measurements in water samples per segment

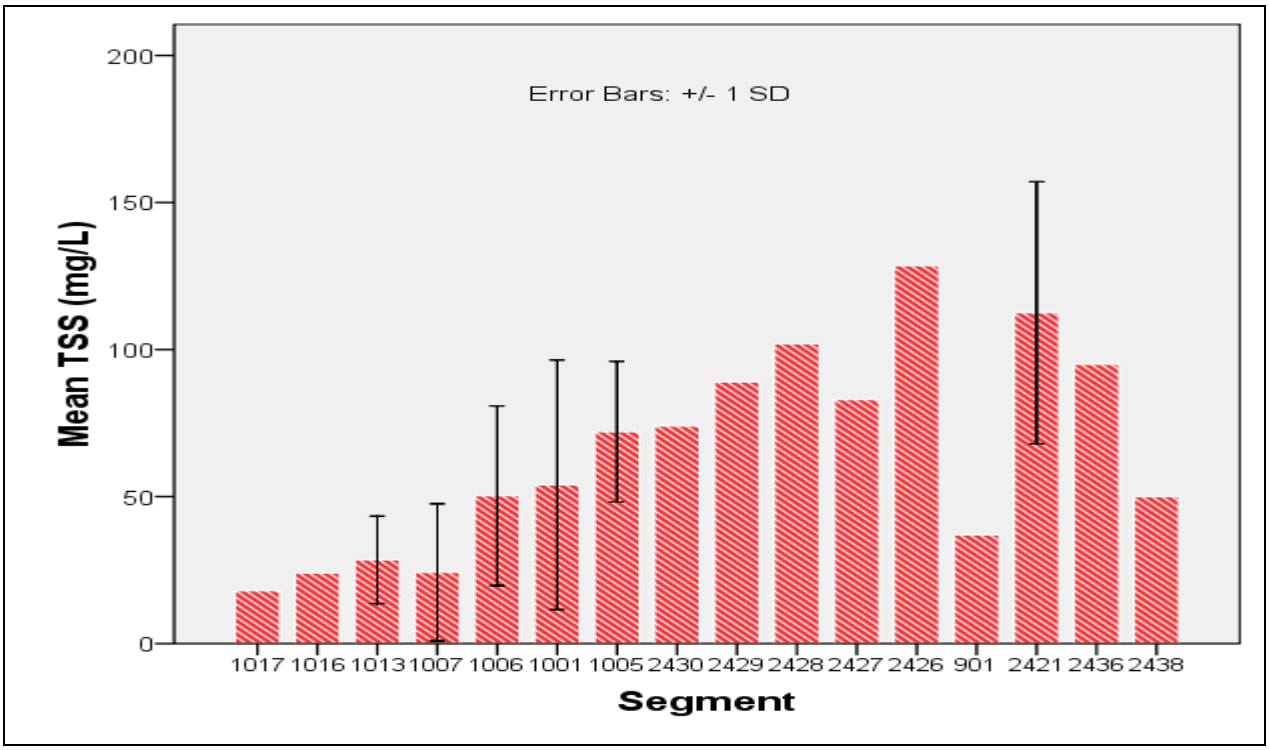

Figure 4.14 Average TSS values in water samples per segment

4.2 In-channel Sediment

Sediment sampling, in addition to PCBs, measured Grain Size, Solids Content, TPH, and TOC (Figures 4.15, 4.16, 4.17, and 4.18, respectively). Table 4.2 summarizes the sediment quality parameters (TOC, TPH and moisture content) by station. The moisture content (%) of sediment is representative of the percent void space or interstitial volume within a bulk sediment sample. Generally larger grain size correlates with lower interstitial volume or pore space (% moisture). The general state of grain size in the Channel shows nearly all silts and clays with a few exceptions that have higher sand content. These higher sand content locations are 11347, 11292, 11262, 16622, 11258, and 16499. These locations are in upper reaches of Buffalo Bayou, San Jacinto River (SJR) and San Jacinto River Tidal, and the Side Bay along the lower reaches of the HSC. Most main channel sediments were smaller in size and more cohesive. TPH results

were high in three locations all in the upper bayou reaches of SJR and Buffalo Bayou, but all other locations registered a non-detect for TPH.

Table 4.2 Sediment quality measurements by station

Station ID	Moisture (%)	TOC (mg/Kg)	TPH (mg/Kg)
13338	57	9900	<50
11287	53	16000	<50
11274	40	10000	<50
11270	54	12000	<50
15979	48	8400	<50
16622	19	2100	95.3
11280	62	17000	<50
11264	58	10000	<50
11193[a]	72	19000	<50
16213	62	12000	<50
11252	63	11000	<50
14560	57	6000	<50
13363	54	9100	<50
16499	48	8700	<50
16618	74	19000	<50
13355	73	14000	<50
13342	65	13000	<50
11262	16	1400	<50
11261	68	15000	<50
11132	51	12000	<50
11258[a]	53	7700	<50
15301[a]	60	18500	<50
13344	49	8900	<50
11347	17	2600	52.7
11292	50	22000	138

[a] Average of duplicate samples, otherwise concentration of a single sample

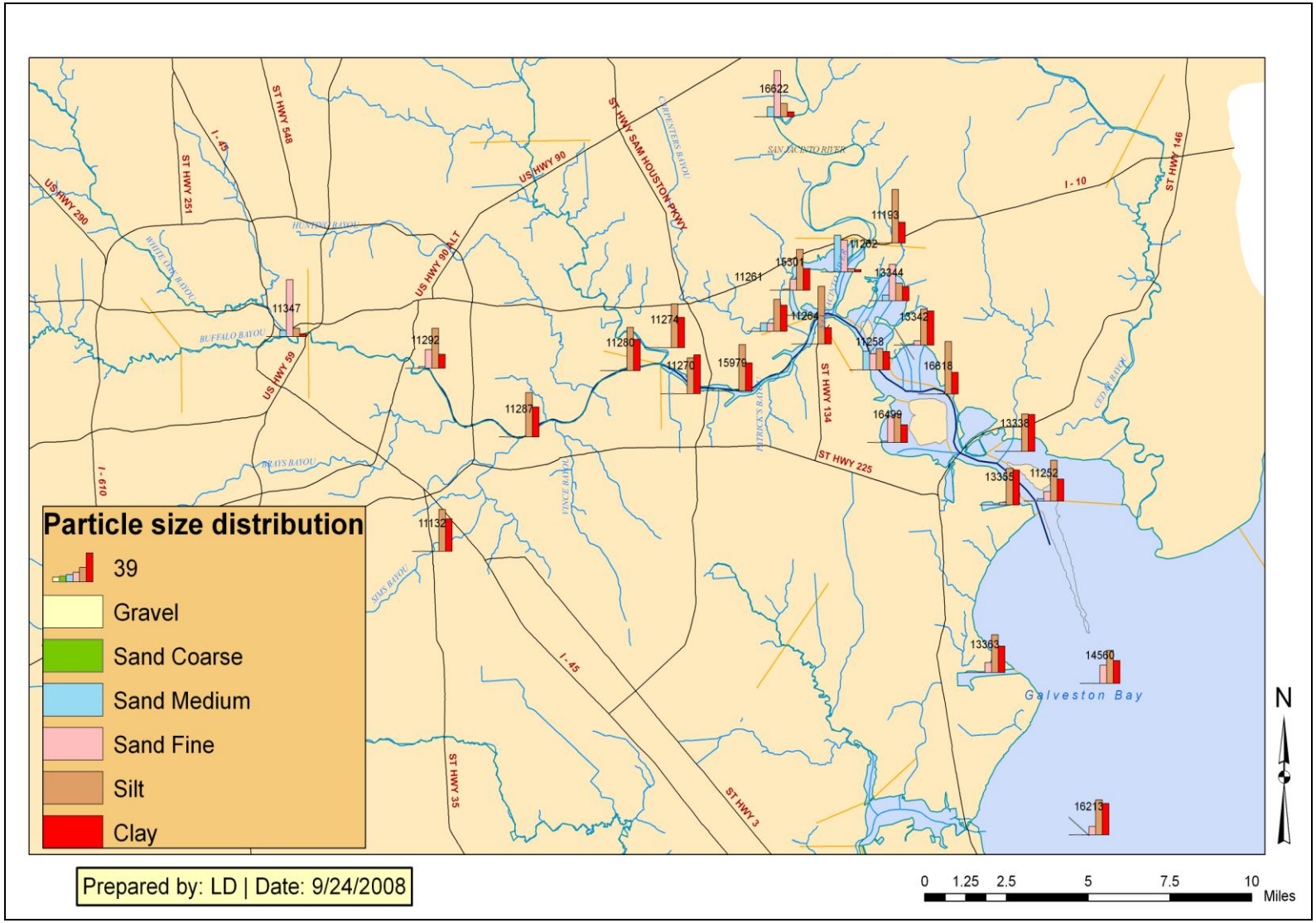

Figure 4.15 Grain size distributions in sediment samples collected in Spring 2008

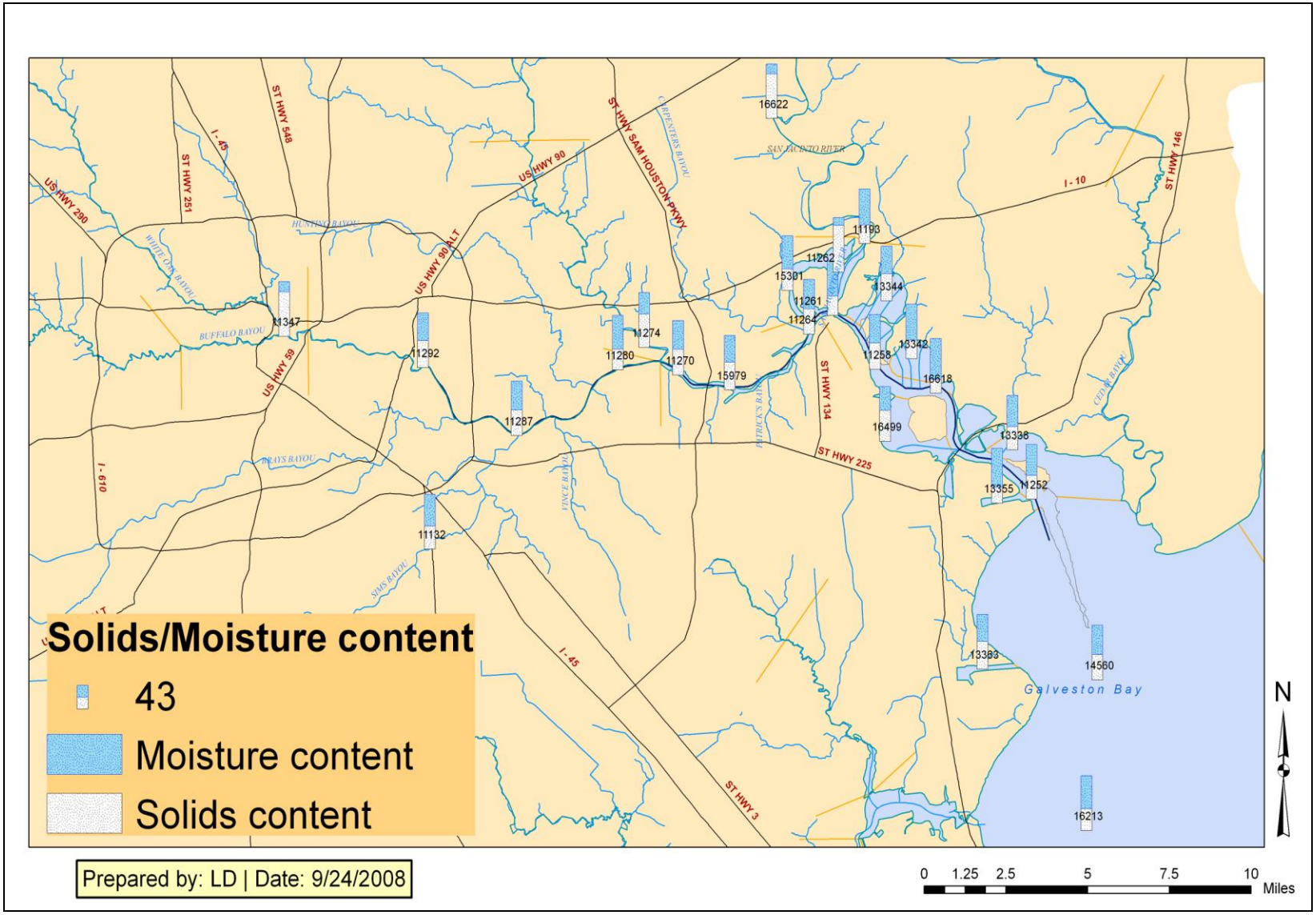

Figure 4.16 Moisture content in sediment samples collected in Spring 2008

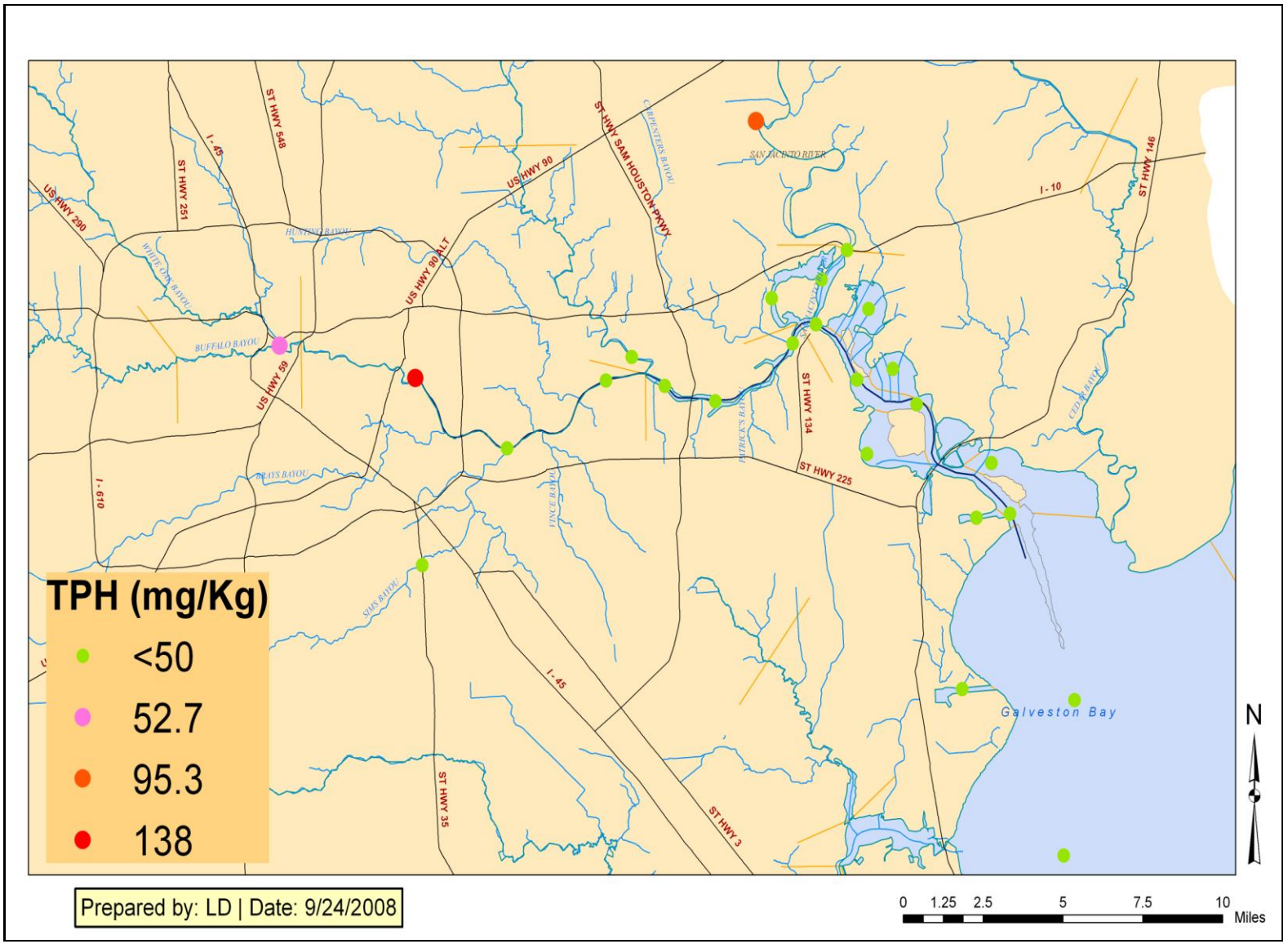

Figure 4.17 Total TPH in sediment samples collected in Spring 2008

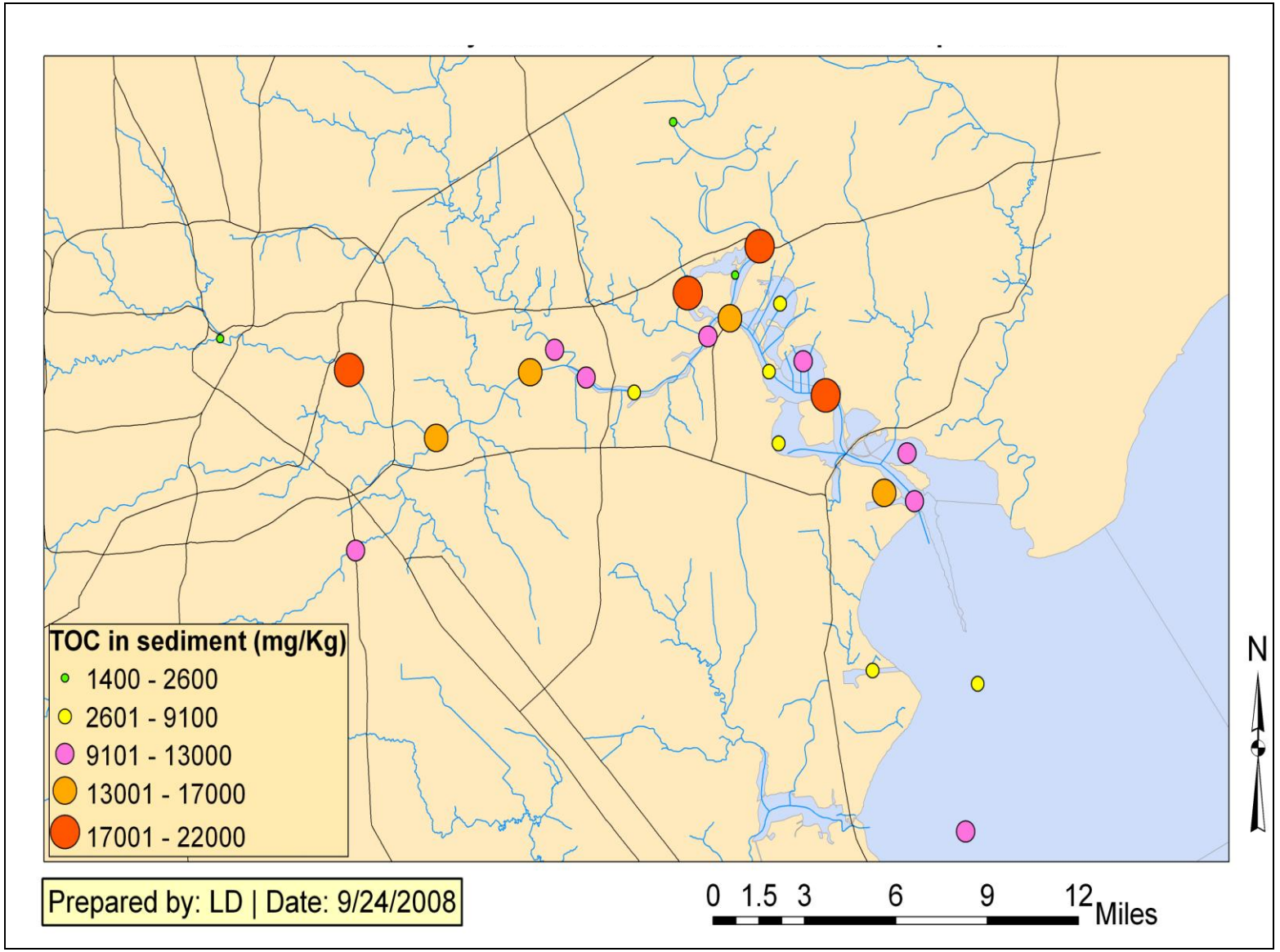

Figure 4.18 TOC in sediment samples collected in Spring 2008

4.3 Tissue

Only a small percentage of fish tissue results have been received at this time, and the only additional parameter measured was the lipid and moisture content of fish. Table 3.3 shows the results received to date.

Table 4.3 Lipid and Moisture Content in tissue samples by station

Sample ID	Species	Lipid (%)	Moisture (%)
15979[a]	Catfish	1.8	78
11264	Catfish	1.5	79
13338	Catfish	1.2	81
11274	Catfish	1.3	81
13338	Seatrout	4.1	79
11264	Seatrout	3.8	79
16622	Catfish	0.96	81
11270	Seatrout	3	76
11270	Catfish	2.3	79
11280	Catfish	1.3	80
11287	Catfish	2.7	80

[a] Average of duplicate samples, otherwise concentration of a single sample

5. SUMMARY OF PCB RESULTS BY MEDIA

5.1 PCB Quality Standards

Several national and state criteria and screening levels for PCBs in water and fish tissue exist. The state/federal Maximum Contaminant Level (MCL) for drinking water is 500 ng/L (ppt), while the human health water quality criteria based on uptake by fish consumption and water recommended by EPA is 0.17 ng/L (U.S. EPA, 1999). The Texas Surface Water Quality Standards (§307.1-307.10) include human health water quality criteria for total PCBs (based on Aroclors) of 1.3 ng/L and 0.885 ng/L in freshwater and saltwater, respectively. These concentrations are lower than the MCL for drinking water due to the fact that the highest exposure potential of PCBs in waters is through the bioaccumulation potential and consumption of contaminated fish (Webster et al., 1998). Additionally, fresh and saltwater criteria differ because it is assumed that consumption rates are higher for saltwater species. The Texas Department of Health based its health assessment of PCBs in the Houston Ship Channel (TDH, 2001) on a screening level of 47 ng-Aroclor/g-tissue. This screening value was derived from an EPA chronic oral reference dose (RfD) for Aroclor 1254 of 0.00002 mg/kg/day[5].

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[5] This is the lower of the carcinogen and noncarcinogen comparison values. The comparison value using the EPA slope factor of 2 $(mg/kg/day)^{-1}$ to account for the carcinogen effects of PCBs was 270 ng/g. Assumptions: bodyweight 70 kg, consumption rate 30 g/day, exposure period 30 yr (for carcinogens), and excess lifetime cancer risk of $1x10^{-4}$.

5.2 PCB Analytical Quantification

PCBs may be quantified as individual congeners, as Aroclor equivalents, or as homolog groups (i.e. monochlorobiphenyl, dichlorobiphenyl, etc). Aroclors are identified as commercial mixtures of PCB congeners. Historically, the most common PCB analysis has been through Aroclor analysis (EPA method 8082). However, the analysis of Aroclor may yield significant error in determining both total PCB and their total toxicity. This is because the Aroclor method assumes that the distribution of PCB congeners in environmental samples and parent Aroclor compounds is similar (U.S. EPA, 2000). Cogliano (1998) found that bioaccumulated PCBs are more toxic and persistent than the original Aroclor mixtures. Thus, the U.S. EPA (2000) recommends analysis of homologue groups or PCB congeners. However, it acknowledges that all health-based assessments are based on Aroclors. U.S. EPA (2000) suggests summing 18 congeners to compare to total PCB or Aroclor-based screening values, as recommended by the National Oceanic and Atmospheric Administration (USEPA, 2000). The 18 congeners include PCB-8, PCB-18, PCB-28, PCB-44, PCB-52, PCB-66, PCB-77, PCB-101, PCB-105, PCB-118, PCB-126, PCB-128, PCB-138, PCB-153, PCB-169, PCB-170, PCB-180, and PCB-187.

For PCBs, the USEPA suggests that each state measures congeners of PCBs in fish and shellfish rather than homologs or Aroclors because they consider congener analysis the most sensitive technique for detecting PCBs in environmental media. Although only about 130 PCB congeners were routinely present in PCB mixtures manufactured and commonly used in the U.S., all 209 possible PCB congeners are analyzed and reported. Despite EPA's suggestion that the states utilize PCB congeners rather than Aroclors or homologs for toxicity estimates, the toxicity literature does not reflect state-of-the-art laboratory science. To accommodate this inconsistency, National Oceanic and Atmospheric Administration (Lauenstein, 1993) recommends the use of 43

congeners documented in McFarland and Clarke (1989), and from the USEPA's guidance documents for assessing contaminants in fish and shellfish (U.S.EPA, 2000; 2000a) to address PCB congeners in fish and shellfish samples. The preceding references recommend using 43 congeners for their likelihood of occurrence in fish, the likelihood of significant toxicity -- based on structure-activity relationships – and for the relative environmental abundance of the congeners. So the 43 suggested congeners were summed to derive a "total" PCB concentration in each sample. Using only a few PCB congeners to determine total PCB concentrations could conceivably underestimate PCB levels in fish tissue. Nonetheless, the method complies with expert recommendations on evaluation of PCBs in fish or shellfish. The 43 congeners include PCB-8, PCB-18, PCB-28, PCB-37, PCB-44, PCB-49, PCB-52, PCB-60, PCB-66, PCB-70, PCB-74, PCB-77, PCB-81, PCB-82, PCB-87, PCB-99, PCB-101, PCB-105, PCB-114, PCB-118, PCB-119, PCB-123, PCB-126, PCB-128, PCB-138, PCB-151, PCB-153, PCB-156, PCB-157, PCB-158, PCB-166, PCB-167, PCB-168, PCB-69, PCB-170, PCB-177, PCB-179, PCB-180, PCB-183, PCB-187, PCB-189, PCB-194, PCB-201.

5.3 Summary of PCB Results in the Houston Ship Channel

During the Summer 2008, concentrations of the 209 PCB congeners (EPA Method 1668A) were analyzed and results obtained for 35 ambient water locations, 25 in-stream sediment locations, and 8 fish locations.

5.3.1 In-stream Water PCB Concentrations

Total concentrations of PCBs in water (dissolved plus suspended fractions) were calculated using three different methods: (i) sum of 18 NOAA congeners (ii) sum of 43 congeners from McFarland and Clarke, and (iii) sum of all 209 congeners. For stations for which duplicate samples were collected, the PCB results for that station were calculated as the average of duplicate and parent sample. The total PCB concentrations were calculated with non-detects assumed to be zero and non detects assumed to be half the detection limit; however, the difference was not very great.[6] The PCB results by station from the three approaches are summarized in Table 5.1and a statistical summary of PCB results is given in Table 5.2. The total PCB concentrations were the highest when calculations were made with summation of 209 congeners followed by the summation of 43 congeners and the lowest was obtained with the summation of 18 congeners. Based on the method of calculation, the PCB concentrations varied substantially and the inferences differed:

1) The summation of 209 congeners yielded total PCB concentrations in the range of 0.469 and 11.185 ng/L with average concentration of 2.213 ng/L for the 35 locations sampled and results obtained. As can be seen in Table 5.1, 28 out of the 35 locations (80%) sampled in Summer 2008 exceeded the Texas Surface Water Quality Standard (WQS) for human health protection of 0.885 ng/L. In addition, the average concentration was higher than the WQS.

[6] Additionally all PCB totals less than all 209 congeners involved the use of coeluant groups as the concentration for the congener needed in the total. For example in a PCB 43 total, PCB-28 co-elutes with PCB-20 as received from the lab. The exact split between the two congeners is not known, and thus, the total of the two was chosen to be representative of the concentration of PCB-28.

2) The summation of 43 congeners as recommended by USEPA yielded total PCB concentrations in the range of 0.17 and 5.044 ng/L with average concentration of 1.013 ng/L for 35 locations sampled and results obtained. As can be seen in Table 5.1, 14 out of the 35 locations (40%) sampled in Summer 2008 exceeded the Texas Surface Water Quality Standard (WQS) for human health protection of 0.885 ng/L. In addition, the average concentration was again higher than the WQS.
3) The summation of 18 congeners as recommended by NOAA yielded total PCB concentrations in the range of 0.144 and 3.319 ng/L with average concentration of 0.742 ng/L for 35 locations. As can be seen in Table 5.1, 9 out of the 35 locations (26%) sampled in Summer 2008 exceeded the Texas Surface Water Quality Standard (WQS) for human health protection of 0.885 ng/L. The average concentration however was lower than the WQS if the calculations were made based on 18 congeners.

Figures 5.1a, 5.1b, and 5.1c show the spatial distribution of total PCBs in water in the Houston Ship Channel System based on calculations made by summation of 209, 43, and 18 congeners respectively. The green circles in the figures indicate the stations that do not exceed the WQS, while the circles in other colors (yellow, pink, orange, and red) exceed the WQS for human health protection of 0.885 ng/L. Figure 5.2 compares the dissolved and suspended phase water PCB concentrations in water. As can be observed, all stations except 11139 had PCB concentrations higher in the dissolved phase than in the suspended phase, possibly due to a higher organic carbon total in the dissolved phase.

Table 5.1 PCB Concentrations in Water (ng/L)

Station ID	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
	Total PCBs (ng/L)[a]	Total PCBs (ng/L)[b]	Total PCBs (ng/L)[a]	Total PCBs (ng/L)[b]	Total PCBs (ng/L)[a]	Total PCBs (ng/L)[b]
11132	2.464	2.448	1.097	1.095	0.853	0.853
11139	0.475	0.418	0.202	0.195	0.150	0.145
11171	0.485	0.441	0.167	0.160	0.144	0.142
11193	2.120	2.094	0.937	0.933	0.720	0.719
11252	0.730	0.708	0.346	0.342	0.244	0.242
11258	1.642	1.635	0.697	0.697	0.558	0.558
11261	2.059	2.051	1.043	1.043	0.717	0.717
11262[c]	1.819	1.795	0.848	0.845	0.627	0.626
11264	2.765	2.740	1.272	1.269	0.878	0.877
11270	3.944	3.920	1.863	1.860	1.371	1.370
11274	6.173	6.154	2.960	2.958	2.126	2.125
11280	3.857	3.831	1.867	1.864	1.401	1.401
11287	3.358	3.329	1.573	1.570	1.165	1.164
11292	3.340	3.335	1.514	1.513	1.106	1.105
11347	3.765	3.760	1.664	1.664	1.257	1.257
11368	1.166	1.148	0.436	0.433	0.361	0.360
11387	1.057	1.038	0.421	0.418	0.342	0.341
13338[c]	1.119	1.084	0.473	0.467	0.374	0.372
13340	0.739	0.700	0.390	0.383	0.261	0.259
13342	1.403	1.396	0.641	0.640	0.475	0.475
13344[c]	1.389	1.375	0.604	0.603	0.463	0.463
13355	1.019	0.988	0.413	0.408	0.338	0.336
13363[c]	1.148	1.134	0.452	0.450	0.385	0.384
14560	1.284	1.262	0.457	0.454	0.399	0.397
15301	2.838	2.822	1.308	1.306	0.911	0.911

Table 5.1 PCB Concentrations in Water (ng/L)

Station ID	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
	Total PCBs (ng/L)[a]	**Total PCBs (ng/L)[b]**	**Total PCBs (ng/L)[a]**	**Total PCBs (ng/L)[b]**	**Total PCBs (ng/L)[a]**	**Total PCBs (ng/L)[b]**
15936	11.185	11.165	5.044	5.043	3.319	3.318
15979	2.243	2.214	1.106	1.102	0.784	0.783
16213	0.605	0.581	0.296	0.292	0.208	0.206
16499	1.661	1.631	0.838	0.835	0.585	0.584
16618	1.638	1.632	0.684	0.683	0.553	0.553
16622	1.181	1.147	0.578	0.573	0.435	0.434
TBD2	0.726	0.716	0.285	0.285	0.244	0.243
TBD5	1.336	1.315	0.574	0.571	0.468	0.467
TBD6	4.265	4.259	2.188	2.187	1.571	1.571
TBD7	0.469	0.463	0.234	0.233	0.165	0.165

∑209 congeners is total PCB concentration calculated as the sum of all 209 congeners

∑ 43 congeners is total PCB concentration calculated as the sum of the 43 congeners from McFarland and Clarke recommended by NOAA and USEPA

∑NOAA 18 congeners is total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA

a Non-detects assumed to be 1/2 detection limit

b Non-detects assumed to be zero

c Average of duplicate samples, otherwise concentration of a single sample

Exceeds the WQS (0.885 ng/L)

Table 5.2 Statistical summary of PCB concentrations in water

	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
	Total PCBs (ng/L)[a]	Total PCBs (ng/L)[b]	Total PCBs (ng/L)[a]	Total PCBs (ng/L)[b]	Total PCBs (ng/L)[a]	Total PCBs (ng/L)[b]
Min	0.469	0.418	0.167	0.160	0.144	0.142
Max	11.185	11.165	5.044	5.043	3.319	3.318
Average	2.213	2.192	1.013	1.011	0.742	0.741
Stdev	2.039	2.042	0.952	0.953	0.643	0.643
95% Confidence level of mean	1.51 - 2.91	1.49 - 2.89	0.69 - 1.34	0.68 - 1.34	0.52 - 0.96	0.52 - 0.96

∑209 congeners is total PCB concentration calculated as the sum of all 209 congeners

∑43 congeners is total PCB concentration calculated as the sum of the 43 congeners from McFarland and Clarke recommended by NOAA and USEPA

∑NOAA 18 congeners is total PCB concentration calculated as sum of the 18 congeners recommended by NOAA

a Non-detects assumed to be 1/2 detection limit

b Non-detects assumed to be zero

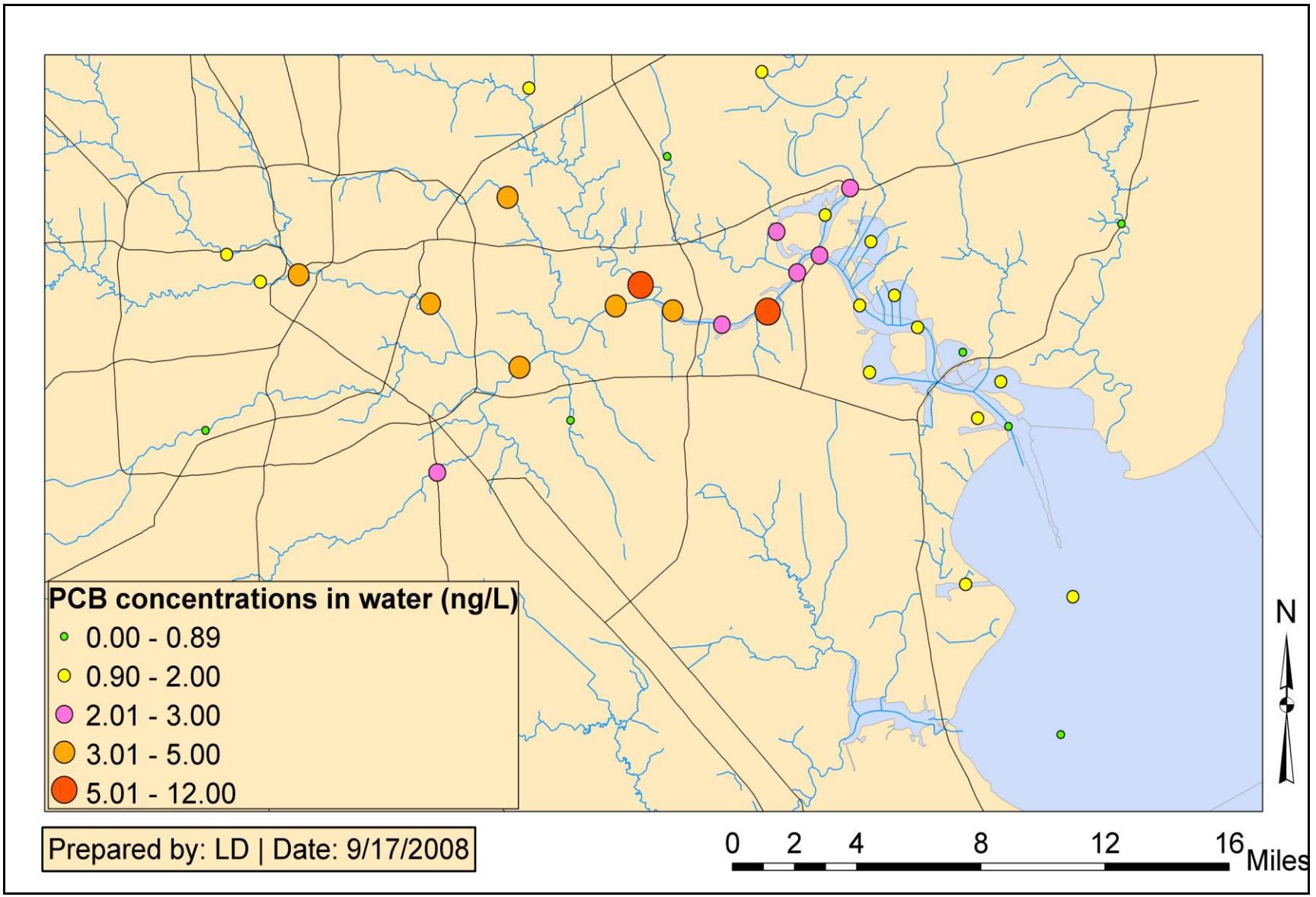


Figure 5.1a Total PCB concentrations in water (Total PCB concentration calculated as the sum of all 209 congeners)

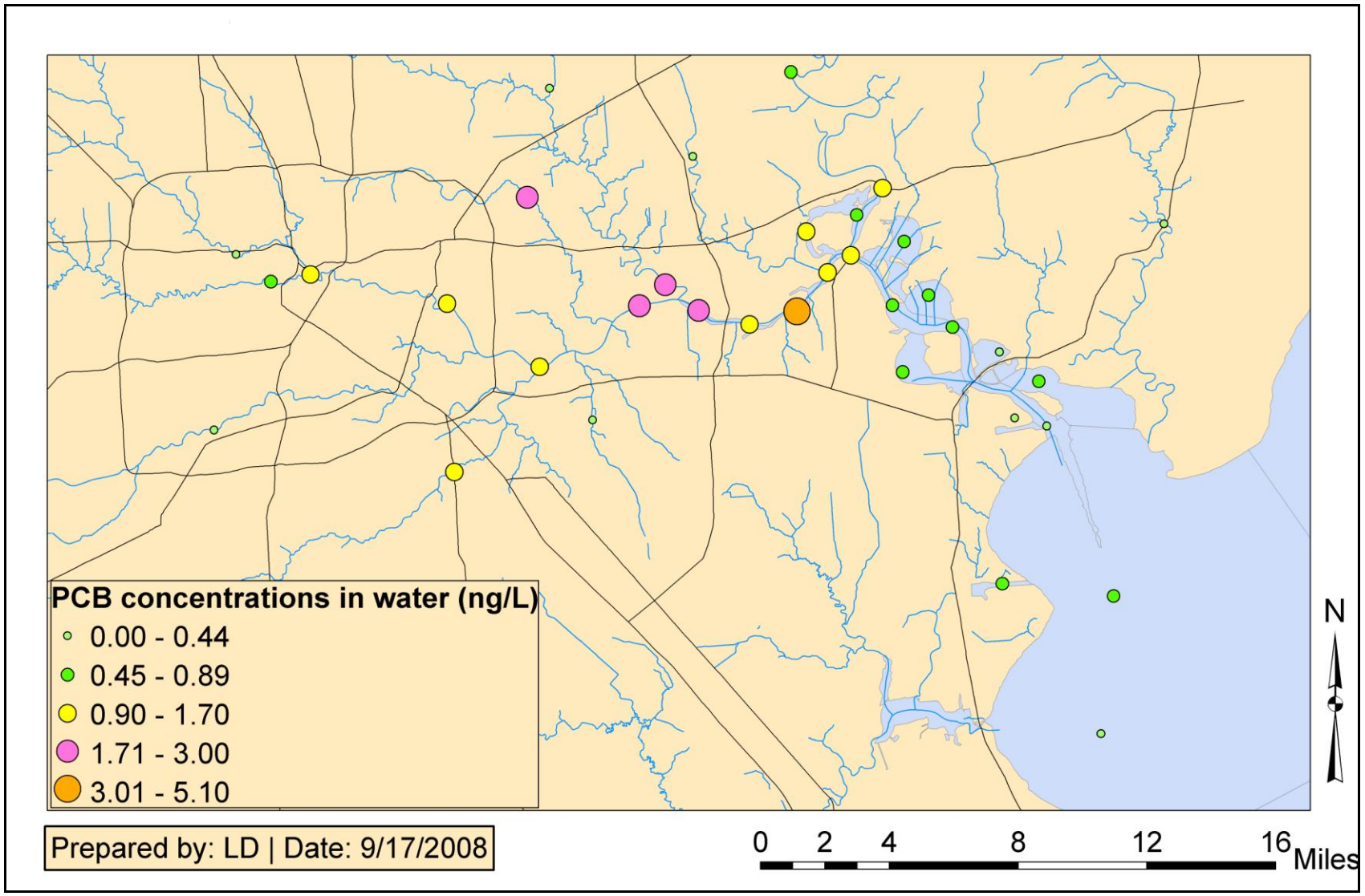


Figure 5.1b Total PCB concentrations in water (Total PCB concentration calculated as the sum of the 43 congeners recommended by NOAA and USEPA).

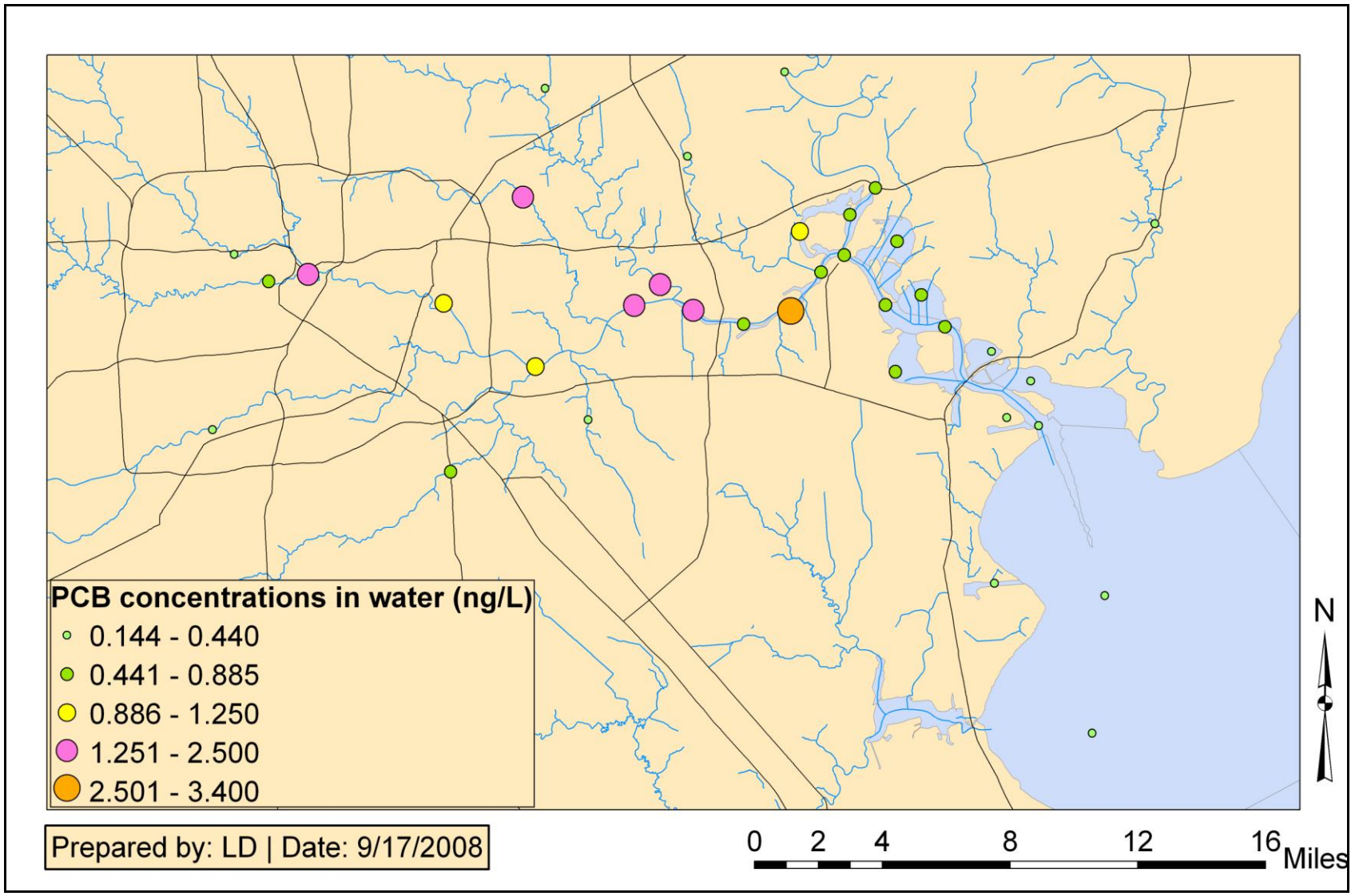
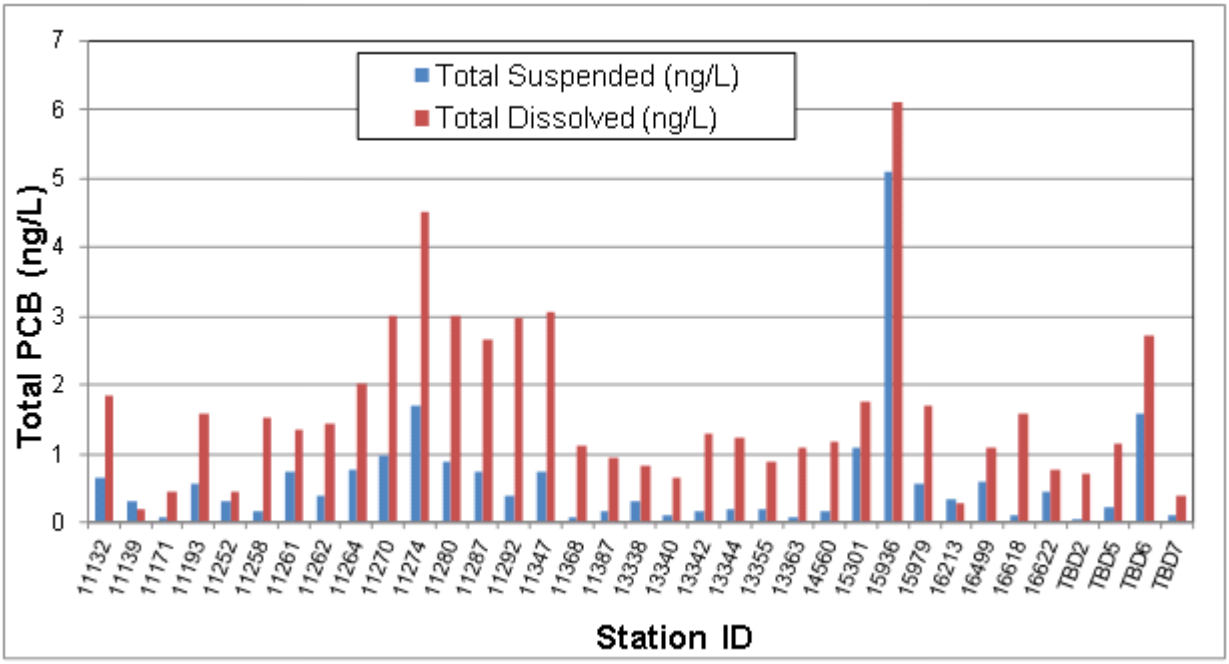


Figure 5.1c Total PCB concentrations in water (Total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA)



* All concentrations based on 1/2 detection limit treatment of non-detects and ∑209 congeners.

Figure 5.2 Partitioning of PCBs between Dissolved and Suspended Phases in the HSC

5.3.2 Sediment PCB Concentrations

PCB results from the in-channel sediment samples collected in Summer 2008 are shown in Table 5.3 by station sampled. Depending on the approach of calculation of total PCBs, the PCB concentrations varied significantly. The summation of 209 congeners yielded total PCB concentrations in the range of 1.4 and 108 ng/g with average concentration of 25 ng/g for 25 locations sampled. The summation of 43 congeners yielded total PCB concentrations in the range of 0.7 and 62 ng/g with an average concentration of 14 ng/g for 25 locations sampled. While the summation of 18 congeners yielded total PCB concentrations in the range of 0.5 and 41 ng/g with an average concentration of 12 ng/g for 25 locations. As expected the total PCB concentration decreased with decrease in the number of congener summation. Figure 5.3a, 5.3b, and 5.3c shows the distribution of total PCBs in sediment in the Houston Ship Channel System

based on calculations made by summation of 209, 43 and 18 congeners, respectively. It can be seen that the higher PCB concentrations in sediment were found upstream of Morgans point compared to concentration downstream of Morgans point. Figure 5.4 shows the correlation that exists between PCB concentrations in sediment to concentrations in water and in general was found to be a good fit.

Table 5.3 PCB Concentrations in Sediment (ng/g-wet wt.)

Station ID	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]
11132	21.712	21.490	12.18	12.17	8.60	8.60
11193[c]	16.543	16.543	11.20	11.15	7.48	7.45
11252	1.975	1.908	0.90	0.85	0.65	0.64
11258[c]	1.552	1.552	1.77	1.74	1.18	1.16
11261	9.081	9.007	3.81	3.81	2.53	2.53
11262	1.531	1.432	0.73	0.72	0.49	0.49
11264	20.460	20.384	10.00	9.97	6.51	6.50
11270	58.329	57.935	32.26	32.21	22.02	22.01
11274	108.374	108.116	62.36	62.35	40.85	40.85
11280	69.546	69.243	38.28	38.26	25.99	25.98
11287	65.859	65.180	36.98	36.82	26.00	25.99
11292	96.569	96.055	54.61	54.59	38.01	38.00
11347	15.090	15.010	9.08	9.07	6.43	6.43
13338	8.909	8.846	4.64	4.61	3.10	3.09
13342	19.355	19.266	9.20	9.20	6.16	6.15
13344	6.282	6.226	3.09	3.08	2.08	2.07
13355	1.377	1.315	0.69	0.68	0.47	0.46
13363	2.514	2.430	1.38	1.32	0.93	0.91

Table 5.3 PCB Concentrations in Sediment (ng/g-wet wt.)

Station ID	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]
14560	2.212	2.128	1.18	1.12	0.89	0.87
15301[c]	20.221	20.221	16.66	16.65	11.10	11.10
15979	46.111	45.986	24.41	24.39	16.49	16.48
16213	2.627	2.548	1.30	1.25	0.82	0.81
16499	24.056	24.002	12.41	12.38	9.42	9.41
16618	2.819	2.777	1.23	1.23	0.84	0.84
16622	1.565	1.463	0.86	0.80	0.64	0.61

∑209 congeners is total PCB concentration calculated as the sum of all 209 congeners

∑ 43 congeners is total PCB concentration calculated as the sum of the 43 congeners from McFarland and Clarke recommended by NOAA and USEPA

∑NOAA 18 congeners is total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA

a Non-detects assumed to be 1/2 detection limit

b Non-detects assumed to be zero

c Average of duplicate samples, otherwise concentration of a single sample

Table 5.4 Statistical summary of PCB concentration in sediment

	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]	Total PCBs (ng/g)[a]	Total PCBs (ng/g)[b]
Min	1.38	1.32	0.69	0.68	0.47	0.46
Max	108.37	108.12	62.36	62.35	40.85	40.85
Average	24.99	24.84	14.05	14.02	9.59	9.58
stdev	31.06	30.94	17.60	17.60	11.93	11.93
95% Confidence level of mean	12.2 - 37.8	12.1 - 37.6	6.8 - 21.3	6.8 - 21.3	4.7 - 14.5	4.7 - 14.5

a Non-detects assumed to be 1/2 detection limit

b Non-detects assumed to be zero

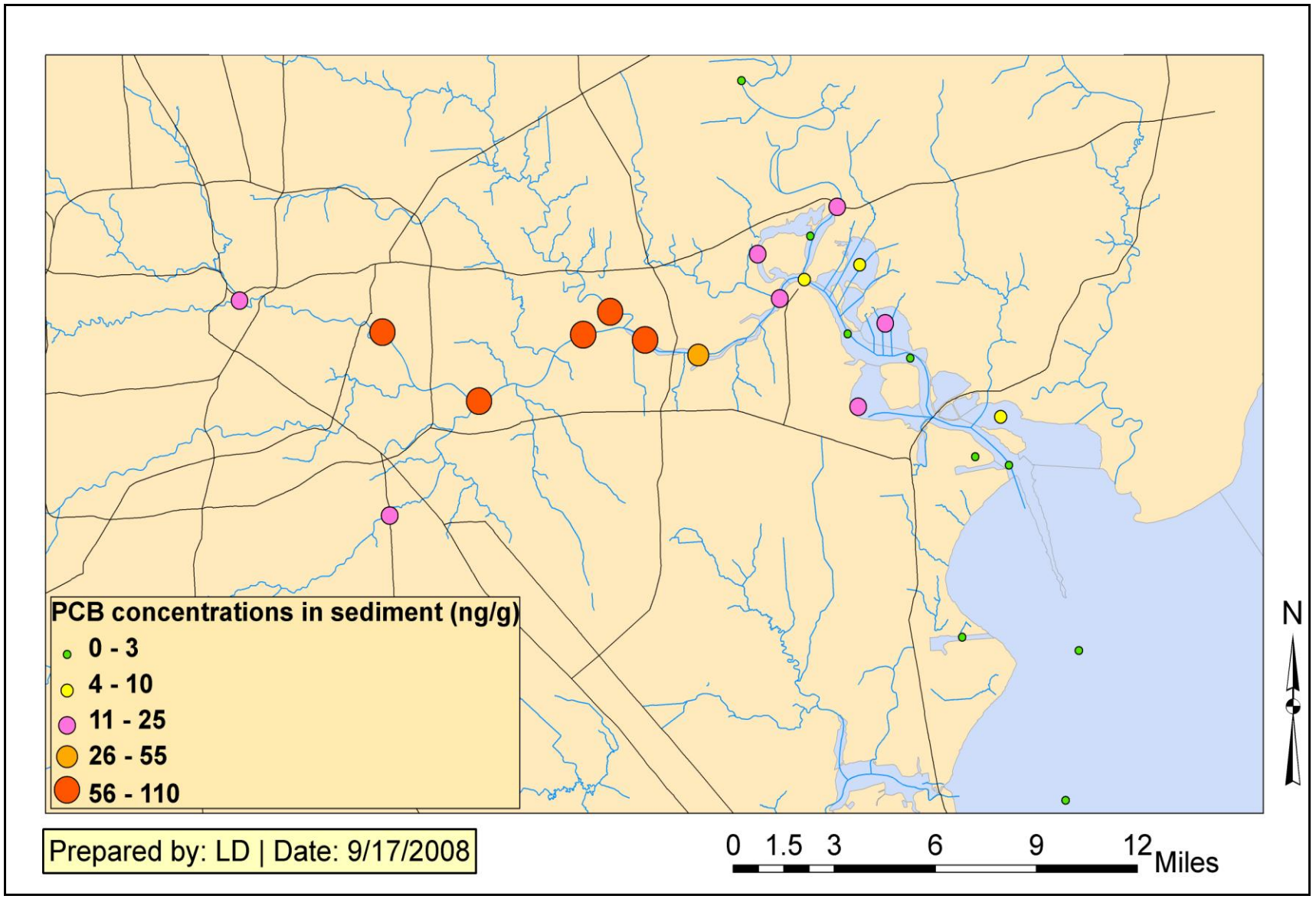


Figure 5.3a Total PCB concentrations in sediment (Total PCB concentration calculated as the sum of all 209 congeners)

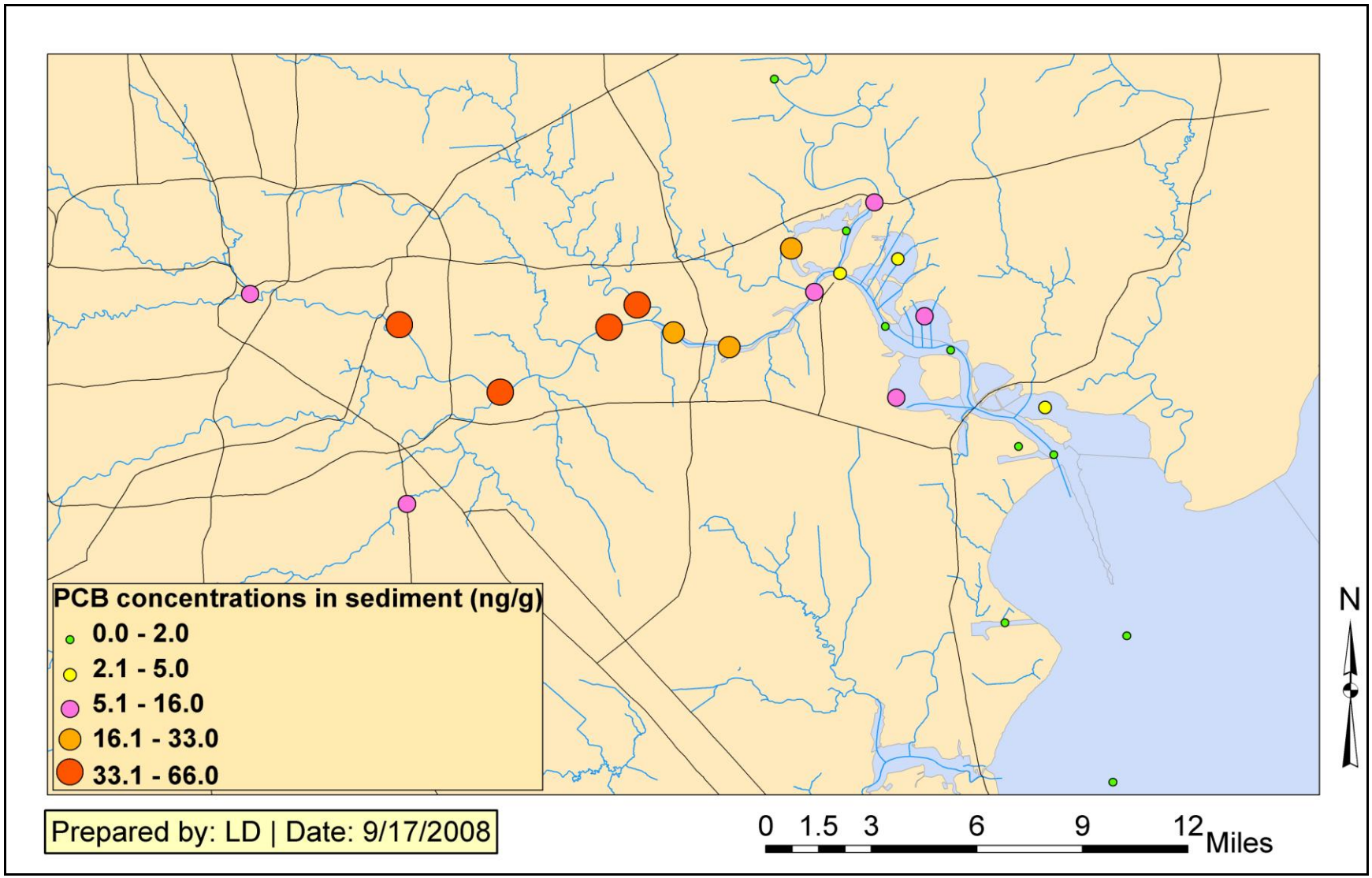


Figure 5.3b Total PCB concentrations in sediment (Total PCB concentration calculated as the sum of the 43 congeners recommended by NOAA and USEPA)

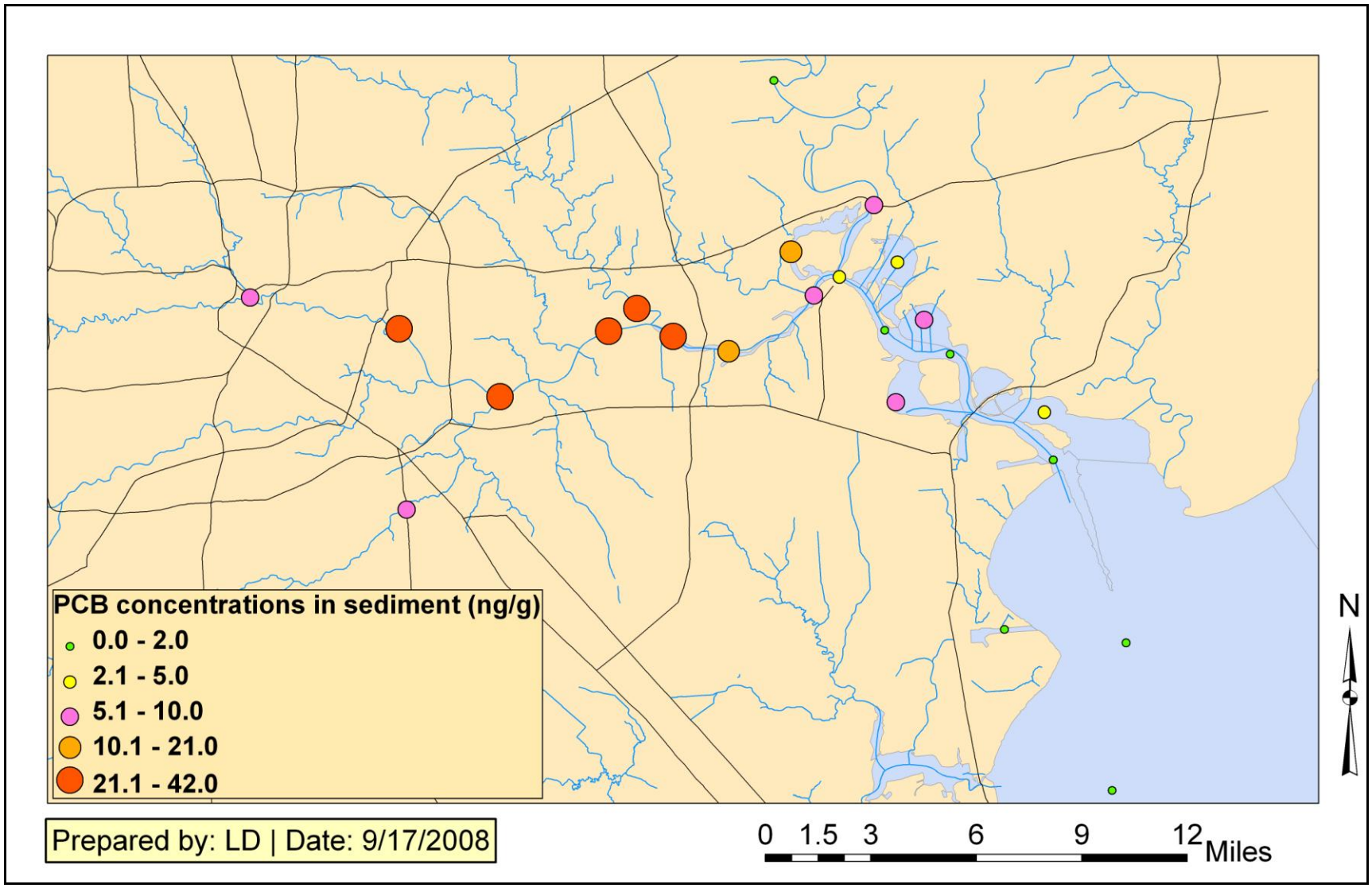
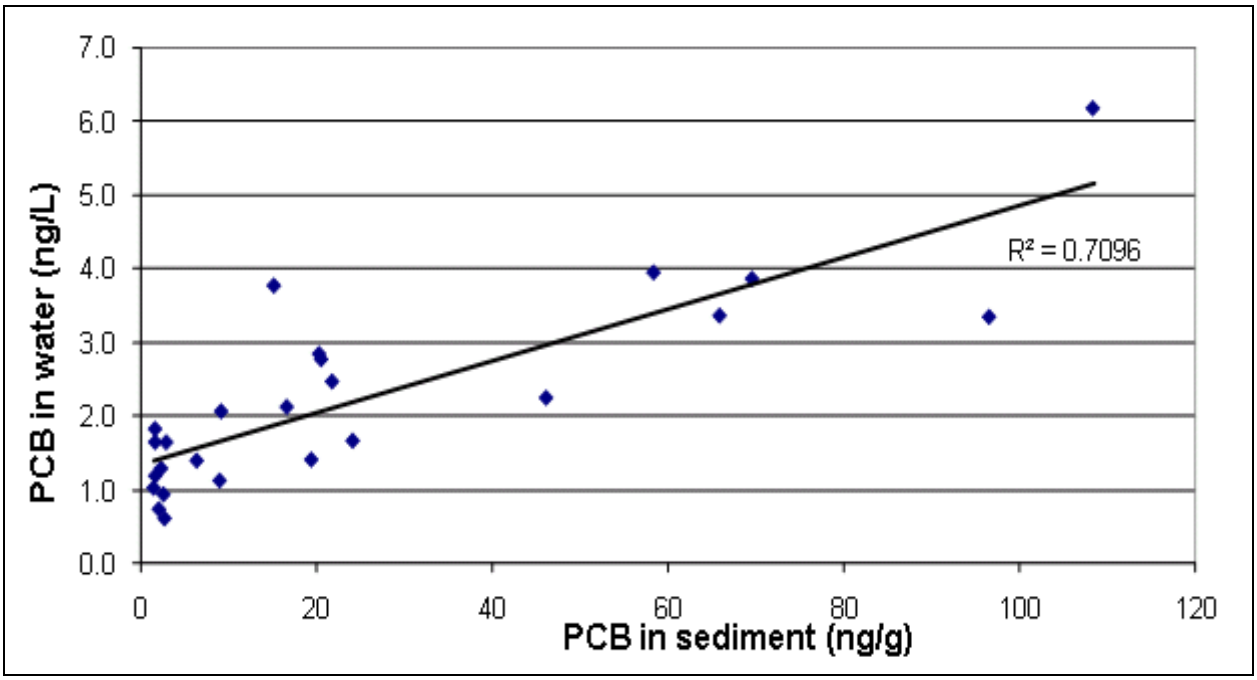


Figure 5.3c Total PCB concentrations in sediment (Total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA)



* All concentrations based on 1/2 detection limit treatment of non-detects and ∑209 congeners.

Figure 5.4 Correlation of PCB concentrations in sediment to concentrations in water

5.3.3 Tissue PCB Concentrations

The total PCB concentrations in catfish and seatrout tissue are given in Table 5.5 by station sampled, while the statistical summary of PCB concentrations in catfish and seatrout are given in Tables 5.6 and 5.7, respectively.

1) The summation of 209 congeners yielded tissue PCB concentrations in the range of 0.012-0.322 mg/Kg in the case of catfish, and 0.146-0.334 mg/Kg in the case of seatrout. As can be seen in Table 5.5, 7 out of the 8 locations (88%) sampled for catfish and 3 out of 3 locations sampled for seatrout exceeded the DSHS Health Assessment Comparison Value (0.047 mg/Kg). In addition, the average concentration of catfish and seatrout was also higher than the Health Assessment Comparison Value.

2) The summation of 49 congeners yielded tissue PCB concentrations in the range of 0.007-0.236 mg/Kg in the case of catfish, and 0.099-0.221 mg/Kg in the case of seatrout. Out of locations sampled and results obtained, 7 out of the 8 locations (88%) sampled for catfish and 3 out of 3 locations sampled for seatrout exceeded the DSHS Health Assessment Comparison Value (0.047 mg/Kg). In addition, the average concentration of catfish and seatrout was also higher than the Health Assessment Comparison Value.
3) The summation of 18 congeners yielded tissue PCB concentrations in the range of 0.005-0.168 mg/Kg in the case of catfish, and 0.068-0.15 mg/Kg in the case of seatrout. Out of locations sampled and results obtained, 6 out of the 8 locations (75%) sampled for catfish and 3 out of 3 locations sampled for seatrout exceeded the DSHS Health Assessment Comparison Value (0.047 mg/Kg). In addition, the average concentration of catfish and seatrout was also higher than the Health Assessment Comparison Value.

The PCB concentrations in catfish and seatrout are mapped in Figures 5.5 and 5.6 for catfish and seatrout, respectively, for the three summation methods. The green fish symbols in the figures indicate the stations that do not exceed the DSHS Health Assessment Comparison Value, while the other fish symbols indicate the exceedances of the DSHS Health Assessment Comparison Value.

Table 5.5 PCB Concentrations in Fish Tissue (mg/Kg-wet wt.)

Station ID	Species	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
		Total PCBs (mg/Kg)[a]	Total PCBs (mg/Kg)[b]	Total PCBs (mg/Kg)[a]	Total PCBs (mg/Kg)[b]	Total PCBs (mg/Kg)[a]	Total PCBs (mg/Kg)[b]
11264	Catfish	0.152	0.151	0.122	0.122	0.090	0.090
11270	Catfish	0.158	0.157	0.124	0.124	0.091	0.091
11274	Catfish	0.279	0.279	0.236	0.236	0.168	0.168
11280	Catfish	0.131	0.129	0.106	0.106	0.077	0.077
11287	Catfish	0.322	0.321	0.218	0.218	0.158	0.158
13338	Catfish	0.073	0.073	0.058	0.058	0.043	0.043
15979	Catfish	0.108	0.108	0.086	0.086	0.063	0.063
16622	Catfish	0.012	0.010	0.007	0.007	0.005	0.005
11264	Seatrout	0.334	0.334	0.221	0.221	0.150	0.149
11270	Seatrout	0.226	0.225	0.154	0.154	0.108	0.108
13338	Seatrout	0.146	0.145	0.099	0.099	0.068	0.068

∑209 congeners is total PCB concentration calculated as the sum of all 209 congeners

∑ 43 congeners is total PCB concentration calculated as the sum of the 43 congeners from McFarland and Clarke recommended by NOAA and USEPA

∑NOAA 18 congeners is total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA

a Non-detects assumed to be 1/2 detection limit

b Non-detects assumed to be zero

c Average of duplicate samples, otherwise concentration of a single sample

Exceeds the TDH Health assessment comparison value (0.047 mg/Kg)

Table 5.6 Summary statistics of PCB concentrations in Catfish

	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
	Total PCBs (mg/Kg)[a]	**Total PCBs (mg/Kg)[b]**	**Total PCBs (mg/Kg)[a]**	**Total PCBs (mg/Kg)[b]**	**Total PCBs (mg/Kg)[a]**	**Total PCBs (mg/Kg)[b]**
Min	0.012	0.010	0.007	0.007	0.005	0.005
Max	0.322	0.321	0.236	0.236	0.168	0.168
Average	0.154	0.154	0.120	0.120	0.087	0.087
Stdev	0.102	0.103	0.077	0.077	0.055	0.055
95% Confidence level of mean	0.069 - 0.24	0.068 - 0.239	0.056 - 0.184	0.056 - 0.184	0.041 - 0.133	0.041 - 0.133

* Most of the 2008 fish data results (~75%) are yet to be received from labs and so statistics are very preliminary

a Non-detects assumed to be 1/2 detection limit

b Non-detects assumed to be zero

Table 5.7 Summary statistics of PCB concentrations in Seatrout

	∑209 congeners		∑43 congeners		∑NOAA 18 congeners	
	Total PCBs (mg/Kg)[a]	**Total PCBs (mg/Kg)[b]**	**Total PCBs (mg/Kg)[a]**	**Total PCBs (mg/Kg)[b]**	**Total PCBs (mg/Kg)[a]**	**Total PCBs (mg/Kg)[b]**
Min	0.146	0.145	0.099	0.099	0.068	0.068
Max	0.334	0.334	0.221	0.221	0.150	0.149
Average	0.235	0.235	0.158	0.158	0.108	0.108
Stdev	0.095	0.095	0.061	0.061	0.041	0.041

* Most of the 2008 fish data results (~75%) are yet to be received from labs and so statistics are very preliminary

a Non-detects assumed to be 1/2 detection limit

b Non-detects assumed to be zero

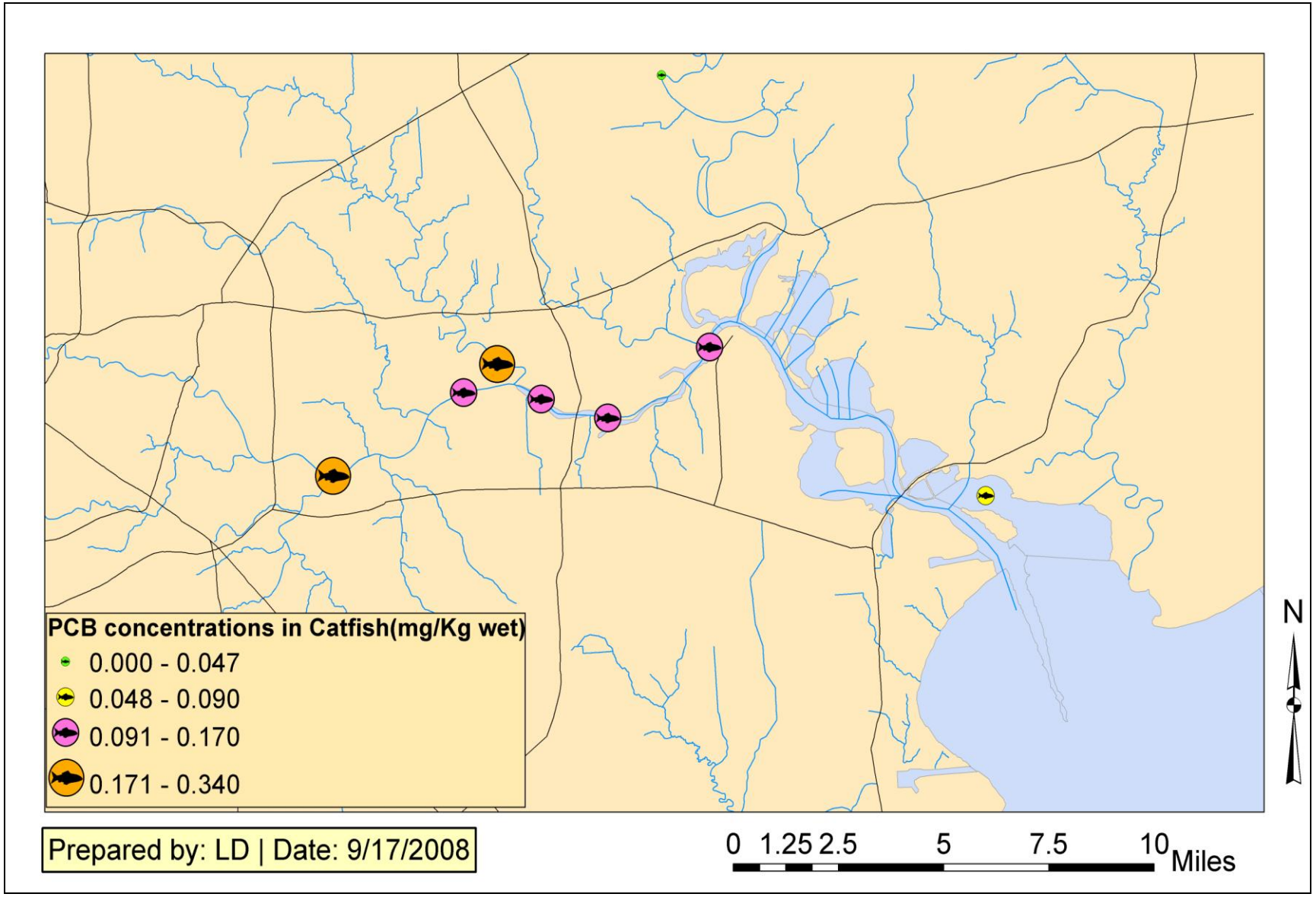


Figure 5.5a Total PCB concentrations in Catfish (Total PCB concentration calculated as the sum of all 209 congeners)

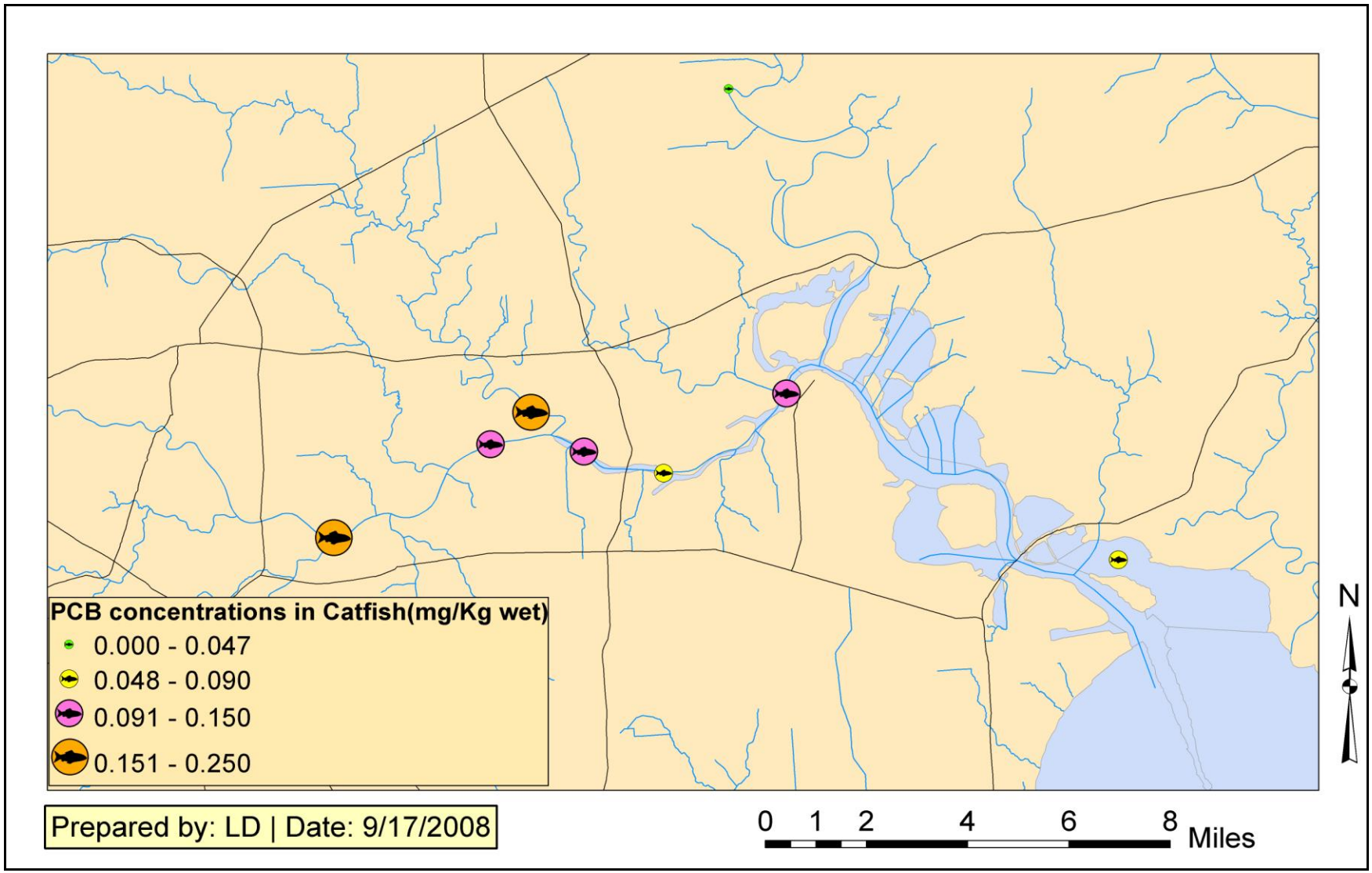


Figure 5.5b Total PCB concentrations in Catfish (Total PCB concentration calculated as the sum of the 43 congeners recommended by NOAA and USEPA)

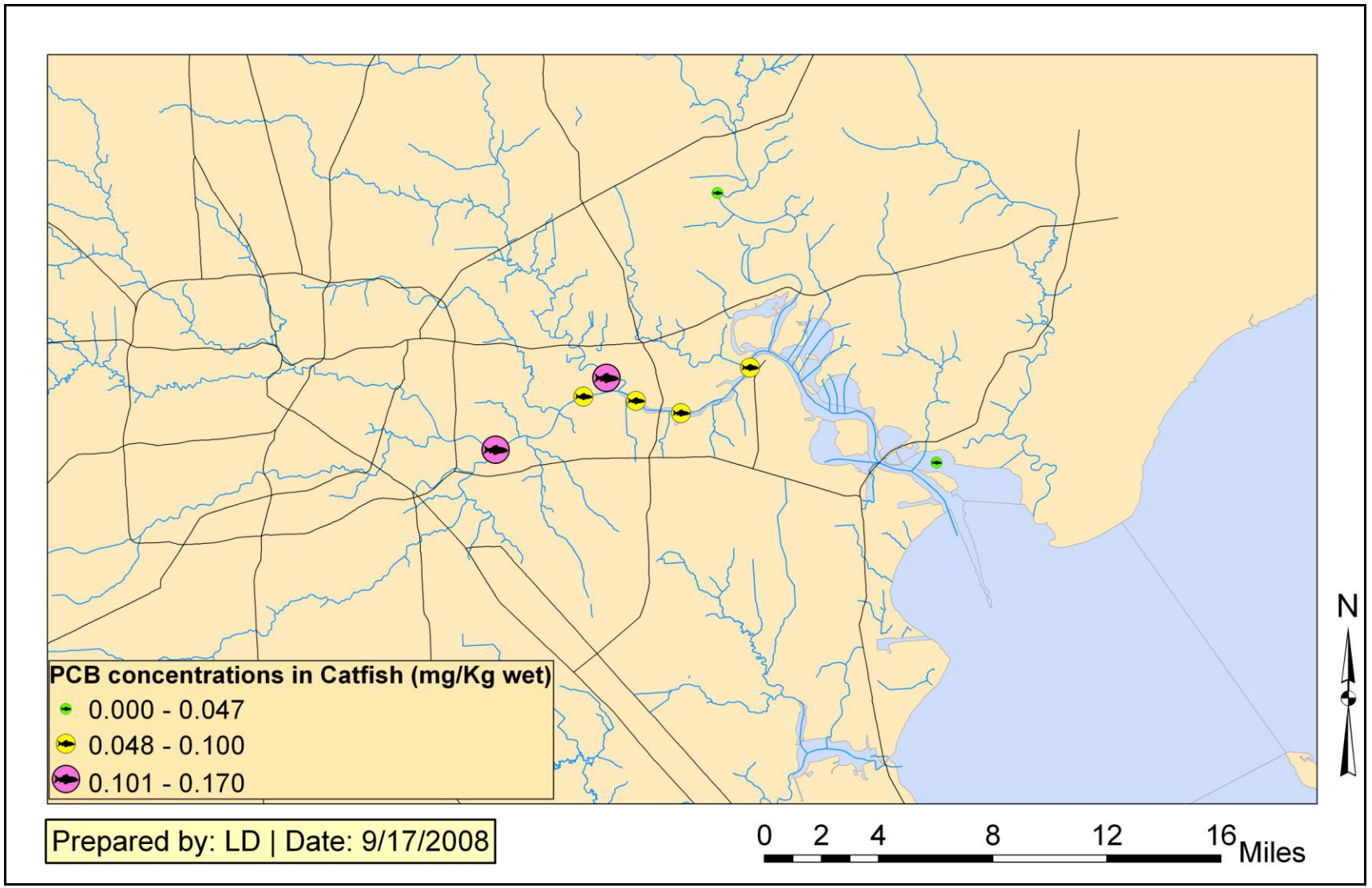


Figure 5.5c Total PCB concentrations in Catfish (Total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA)

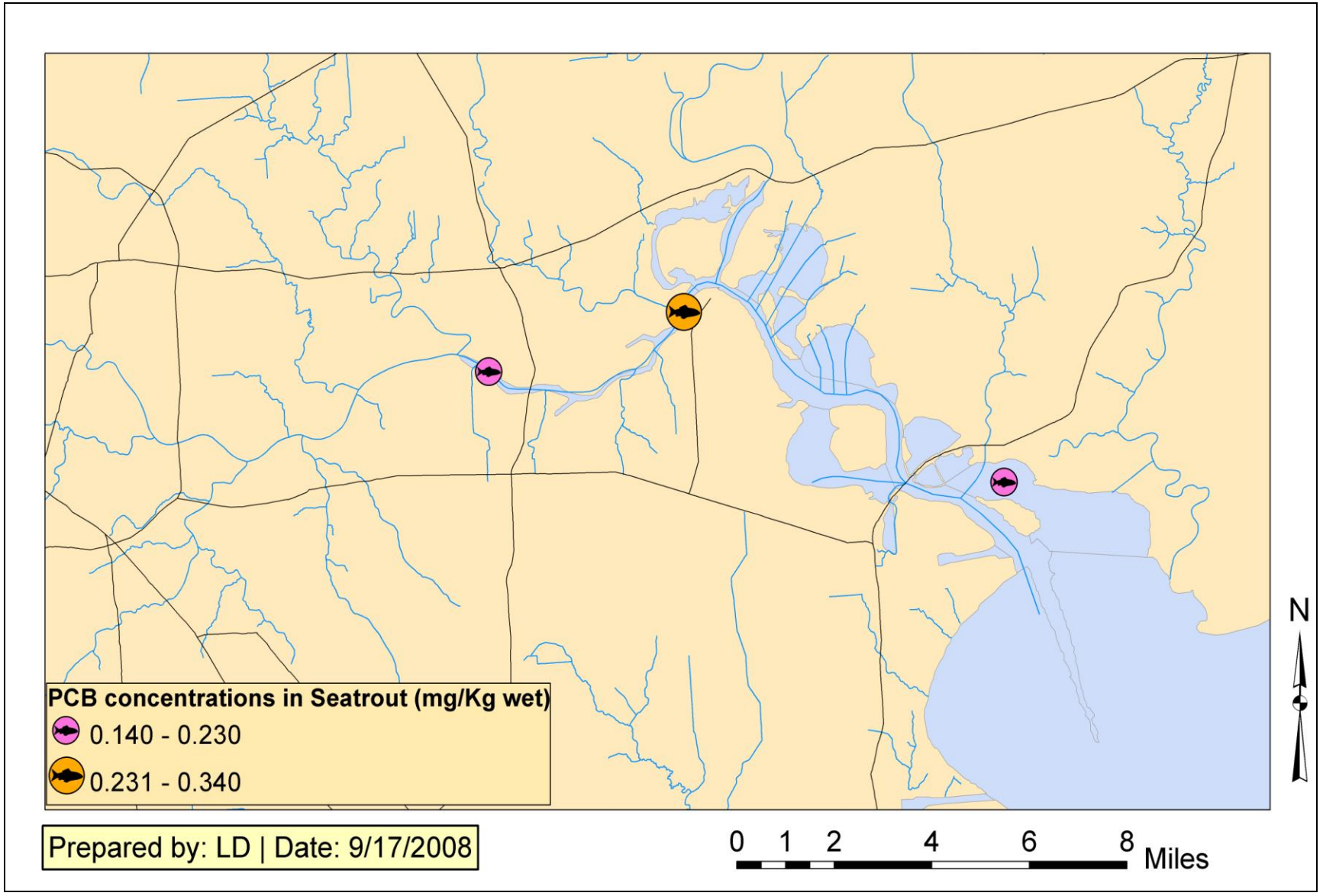


Figure 5.6a Total PCB concentrations in Seatrout (Total PCB concentration calculated as the sum of all 209 congeners)

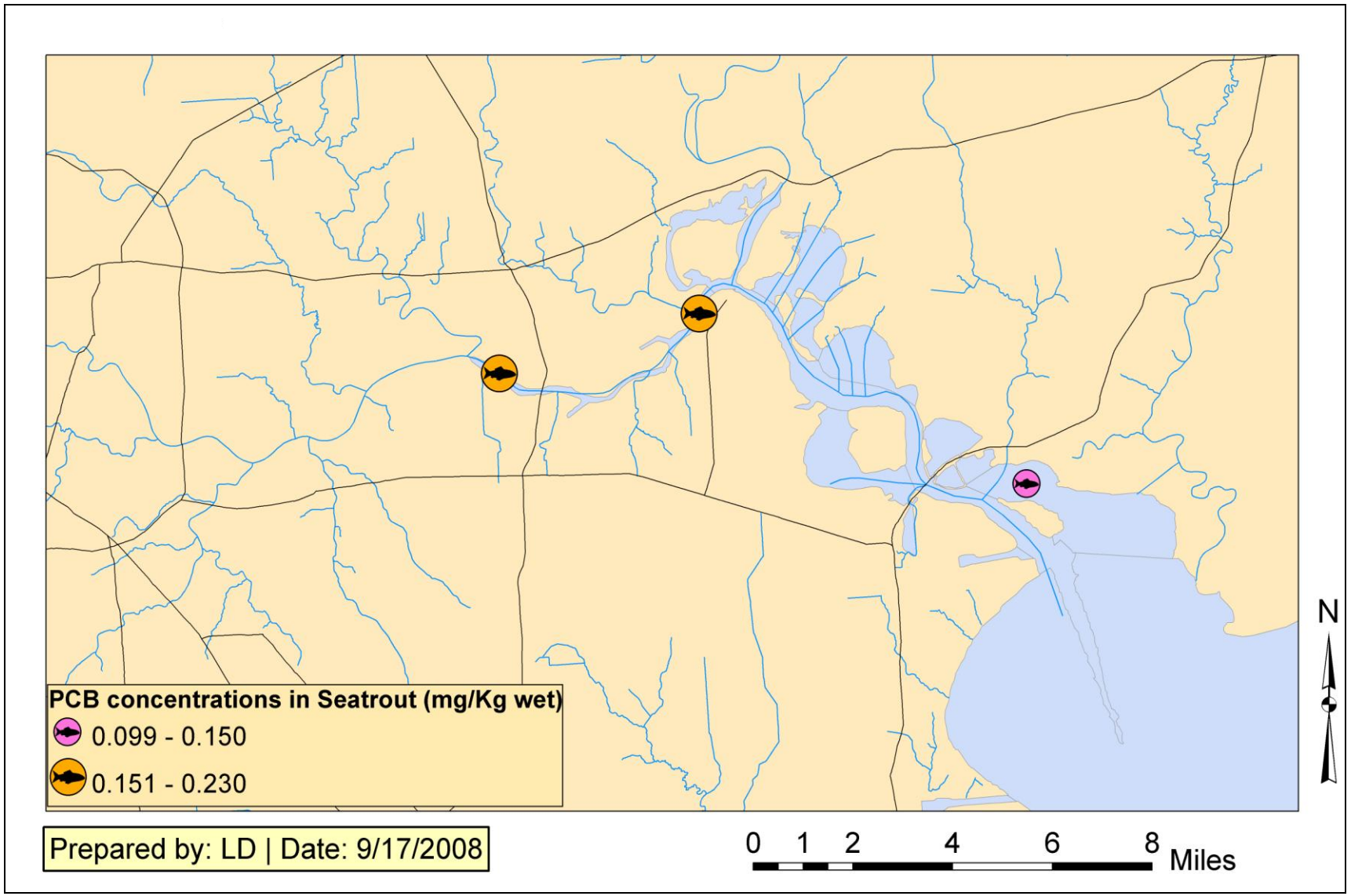


Figure 5.6b Total PCB concentrations in Seatrout (Total PCB concentration calculated as the sum of the 43 congeners recommended by NOAA and USEPA)

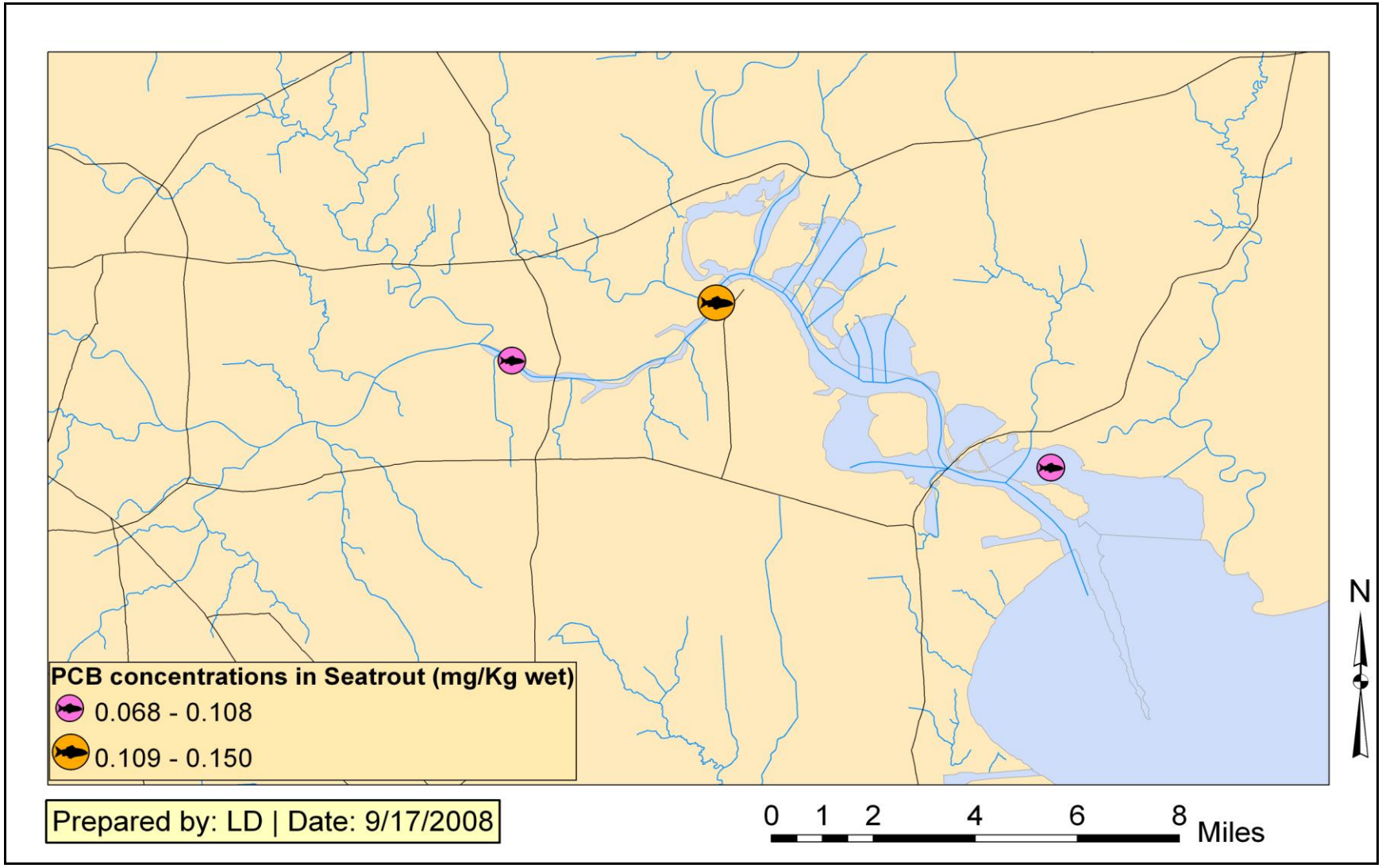


Figure 5.6c Total PCB concentrations in Seatrout (Total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA)

5.4 Tissue PCB Comparison to Other Datasets

Recently, the Texas Department of State Health Services (TDSHS) issued Fish and Shellfish Consumption ADV-35. It was an advisory on all catfish and spotted seatrout from Galveston and Trinity Bays. The following is a comparison of fish tissue data from the 2002-2003 UH PCB fish dataset, the 2008 UH PCB fish dataset, and the 2008 TDSHS fish dataset (TDSHS, 2008a; TDSHS, 2008b) from upper and lower Galveston Bay.

Figures 5.7a and 5.7b show the PCB concentrations in catfish tissue from 2002-2003 and 2008 UH studies respectively. The comparison shown in Figure 5.8 highlights the difference in PCB results of the 43 congener sum between the 2002-2003 UH PCB fish data and the 2008 UH PCB fish data. The dataset of 2008 is not complete but what can be seen in locations that are the same between the two time frames is that the high result at 16622, Banana Bend, is much lower in 2008 than in 2002-2003. Since that concentration was the highest in the 2002-2003 dataset (1096 ng/g wet), it was interesting to see that the concentration was not only lower but also less than the tissue standard. Additionally, 16622 was the only station in the 2008 dataset that has been thus far analyzed that meets the tissue standard. The only other appreciable difference between the datasets is at station 11274, Greens Bayou tidal at Mechling Barge Lines, where it is seen that the concentration is nearly double what was seen in 2002-2003. As Greens Bayou has been an area of concern for some of the highest PCB sediment concentrations (based on 2002-2003 sediment data), it is significant that the tissue concentration has increased here compared to last sampling and that, of the results thus far received, it is the highest fish tissue PCB concentration of the 2008 dataset.

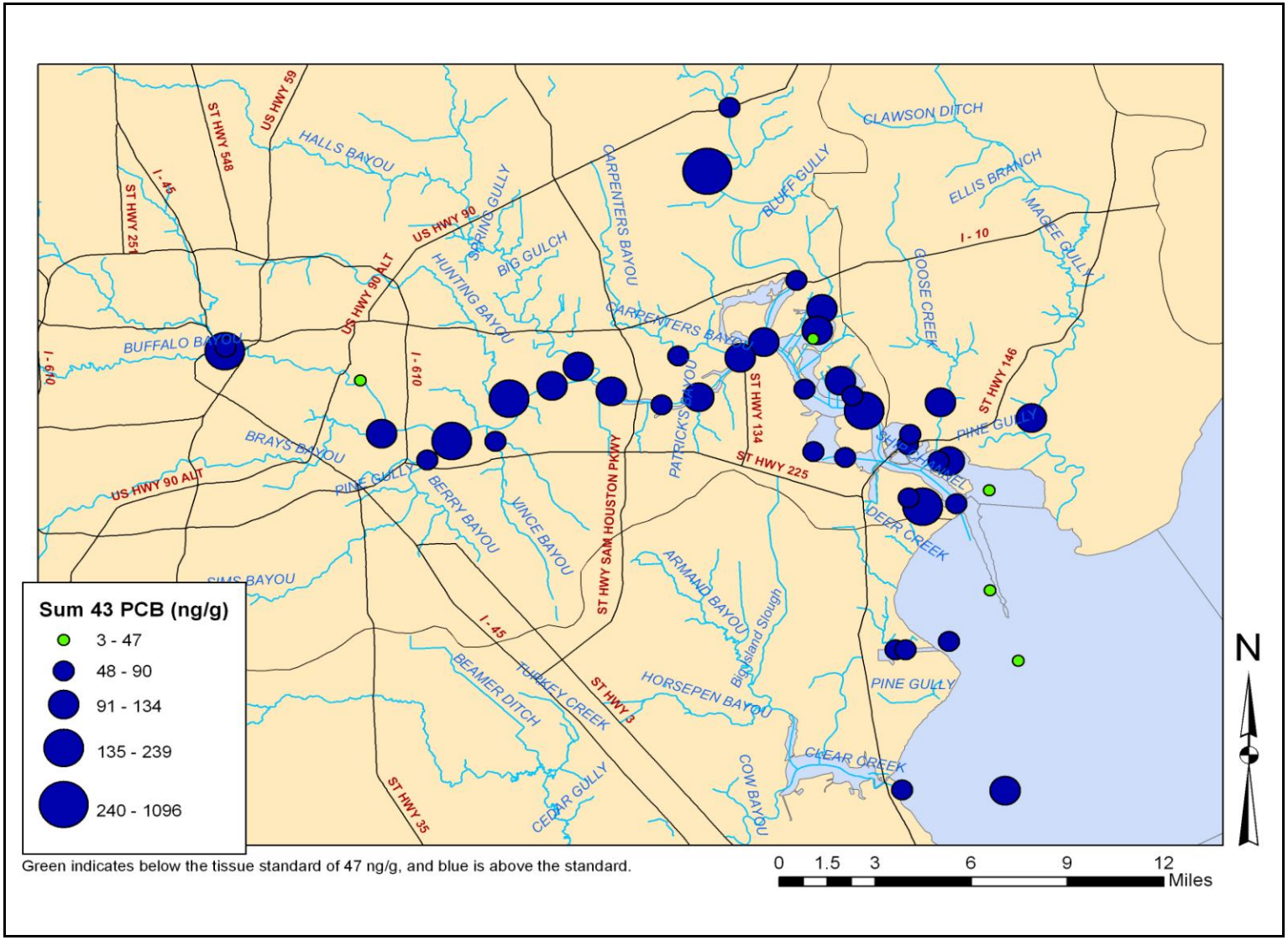


Figure 5.7a Map of PCB catfish tissue concentration in 2002-2003

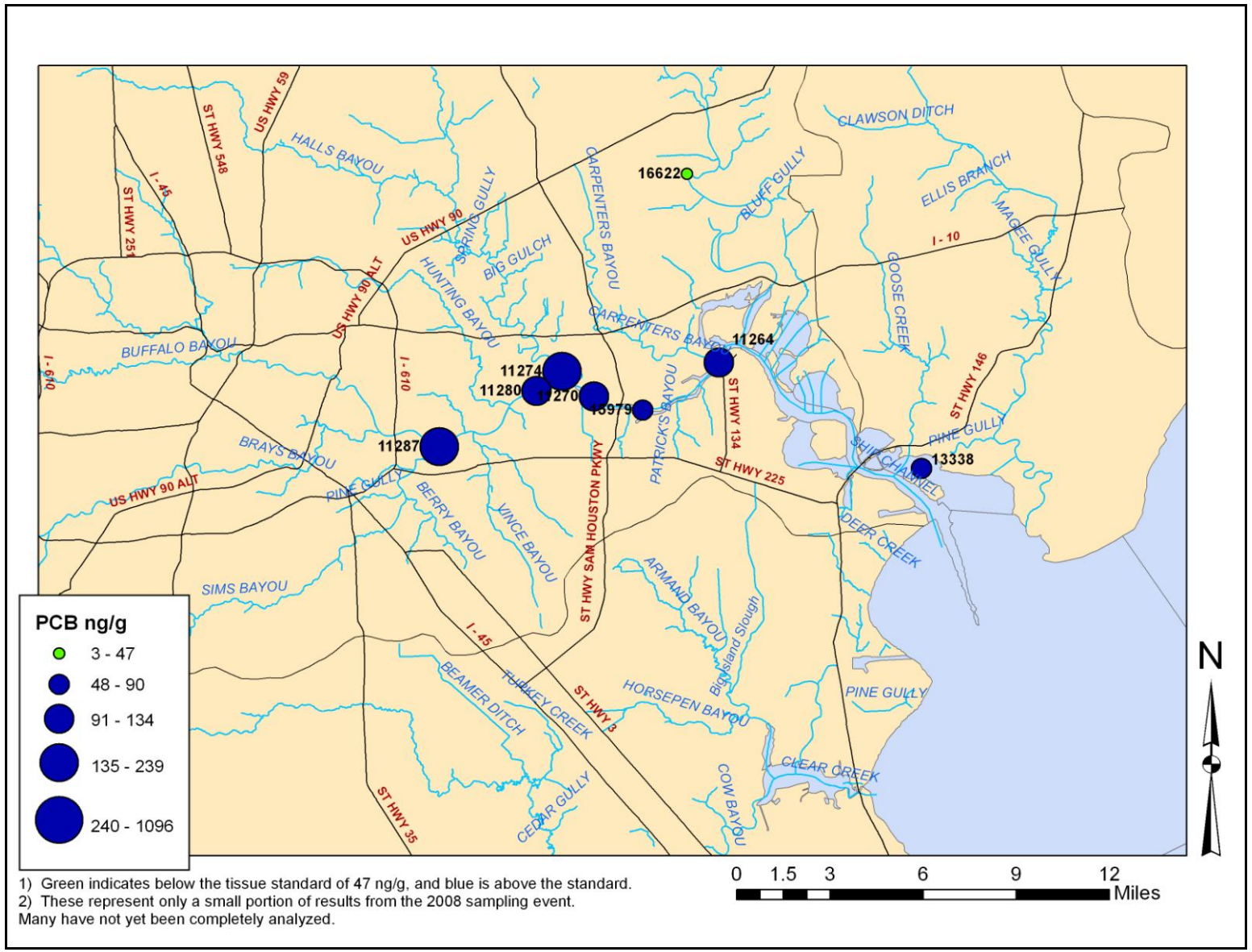


Figure 5.7b Map of PCB catfish tissue concentration in 2008

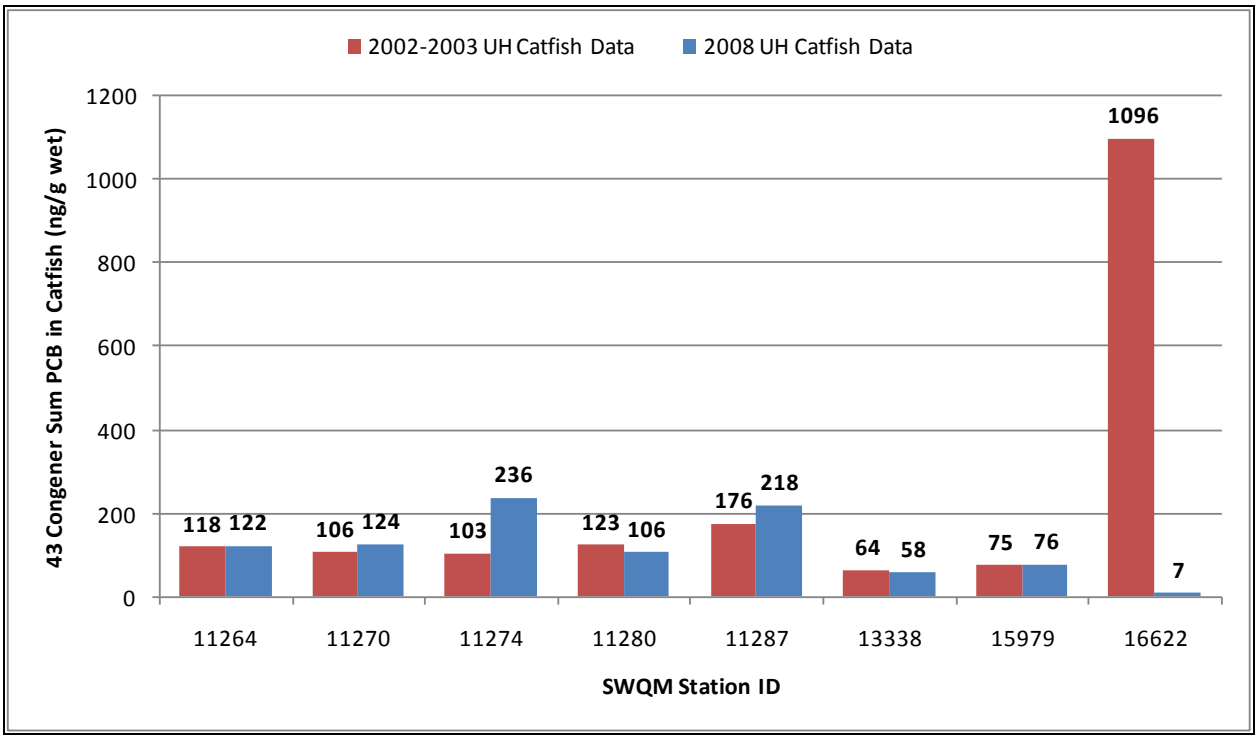
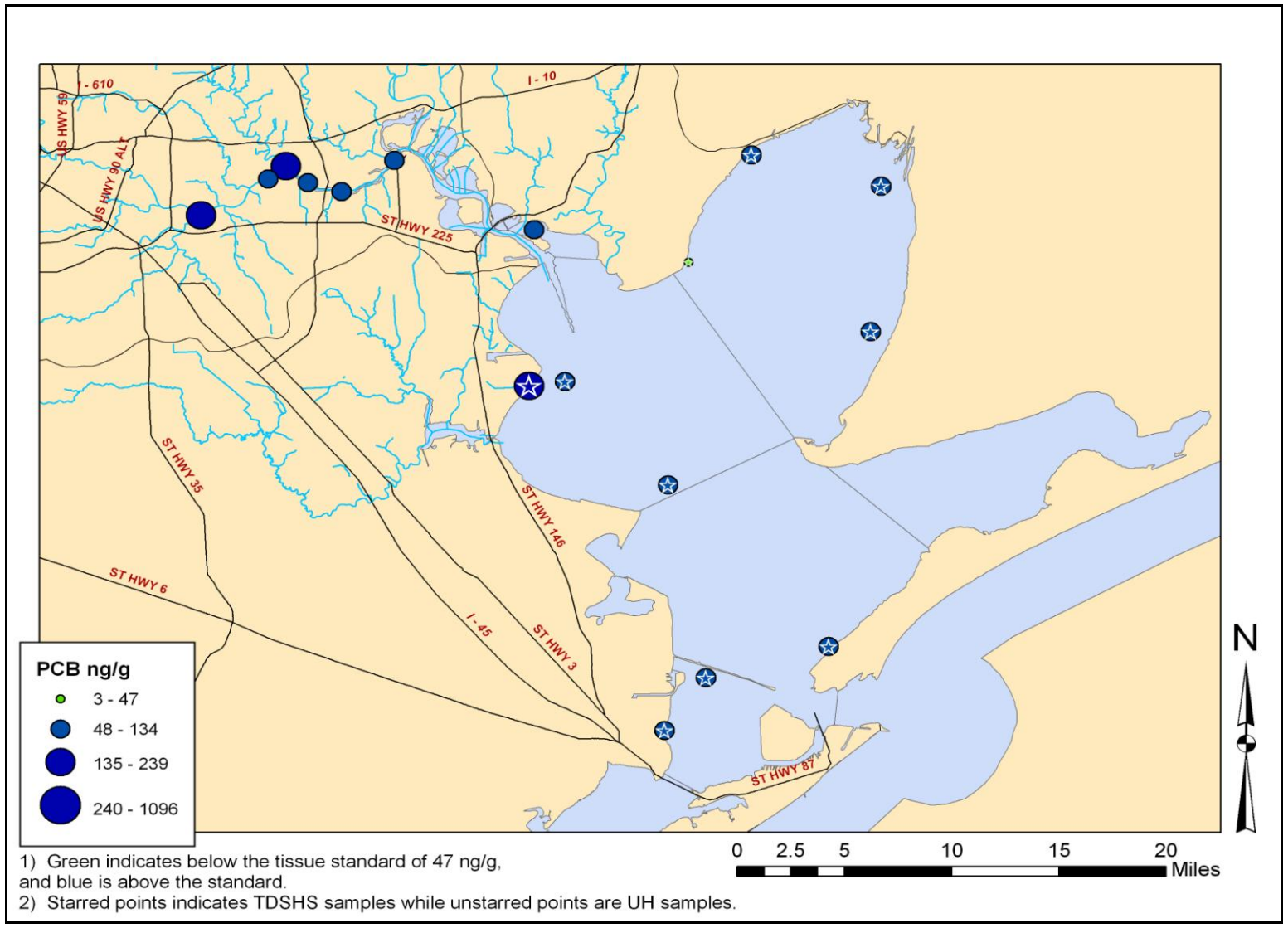


Figure 5.8 PCB catfish tissue concentration comparison between 2002-2003 and 2008

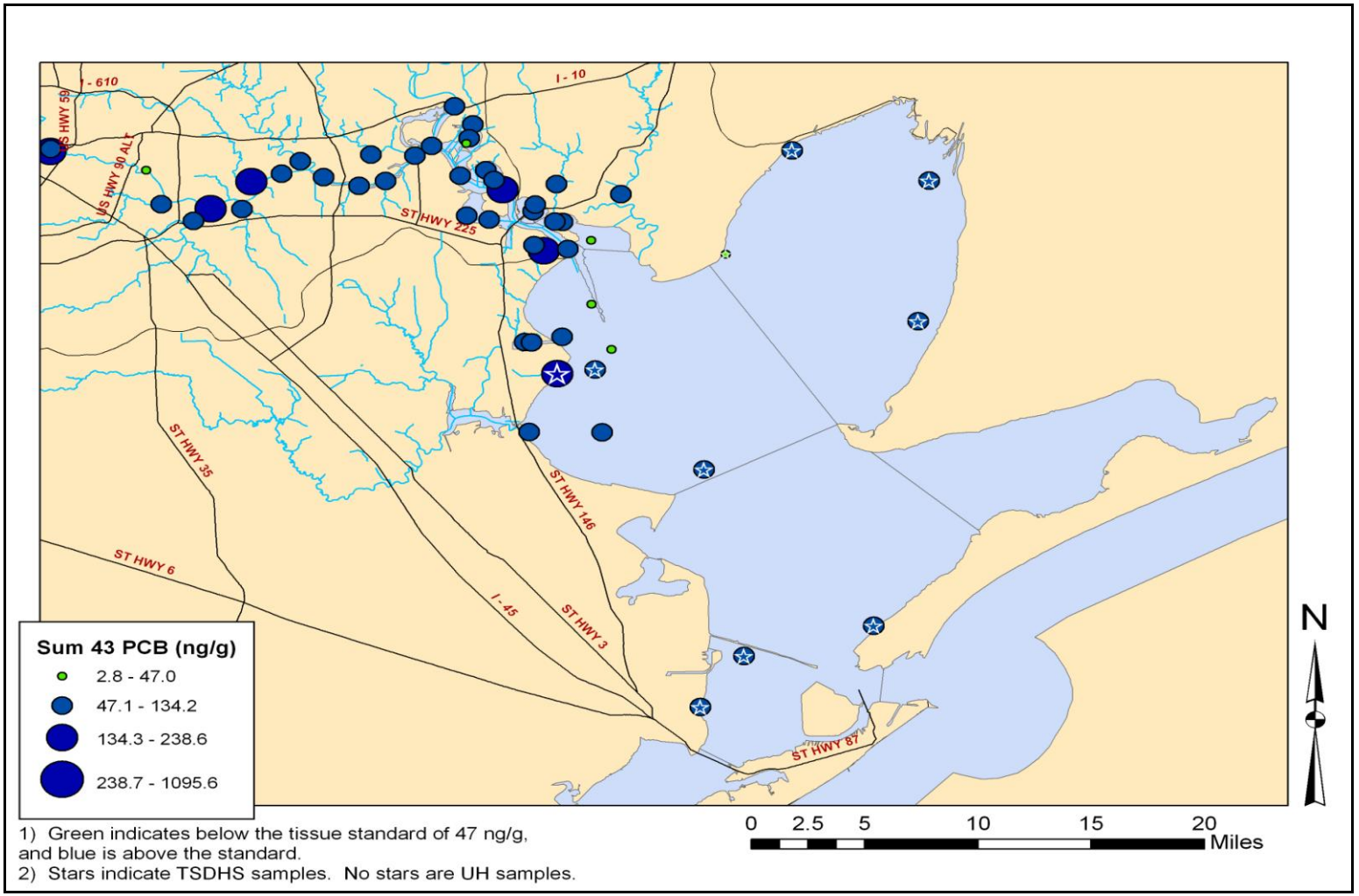
A comparison was also made between the UH fish tissue PCB datasets and that of the TDSHS datasets. The data was essentially collected from different regions of the HSC-Galveston Bay system. UH data was more HSC focused while TDSHS was more Galveston Bay focused. The differential regional foci allow for some comparisons to be made in terms of the level of PCB impairment in fish tissue. Figure 5.9a compares the PCB concentrations in catfish between 2008 UH data and 2008 TDSHS data, while Figure 5.9b compares the PCB concentrations in catfish between 2002-2003 UH data and 2008 TDSHS data. A visual inspection shows that the TDSHS data (starred data) is lower than the UH data from either timeframe (further corroborated by the histograms in Figure 5.10) and that the only TDSHS concentration that come close to the

higher concentrations found in the Channel is at a near shore station just south of Bayport Channel called Pine Gully. While it seems plausible to say that catfish concentrations are higher in the Channel than in either the upper or lower bay, it is more difficult to say from the figure that the concentrations are attenuating in the bay as one moves further from Morgan's Point and out into the Gulf. Some of this difficulty in trend analysis is explainable from the knowledge of fish migration. In other words, there is no guarantee that a fish caught at a particular location has been substantially exposed to the water and sediment in that location. Finally, these figures show that there are few stations for catfish that meet the tissue quality standard of 47 ng/g wet. One notable exception is the 2002-2003 catfish samples taken just at and south of Morgan's point that are farther away from the shoreline. These stations are 13336, Tabbs Bay at Channel Marker 14; 13309, Upper Galveston Bay at Channel Marker 83; and 13307, Upper Galveston Bay at Channel Marker 75. None of the TDSHS samples were taken that far from some coastal location, but these samples taken in 2002-2003 seem to indicate that there may be near-shore effects that increase PCB concentrations for fish caught closer to the shoreline.



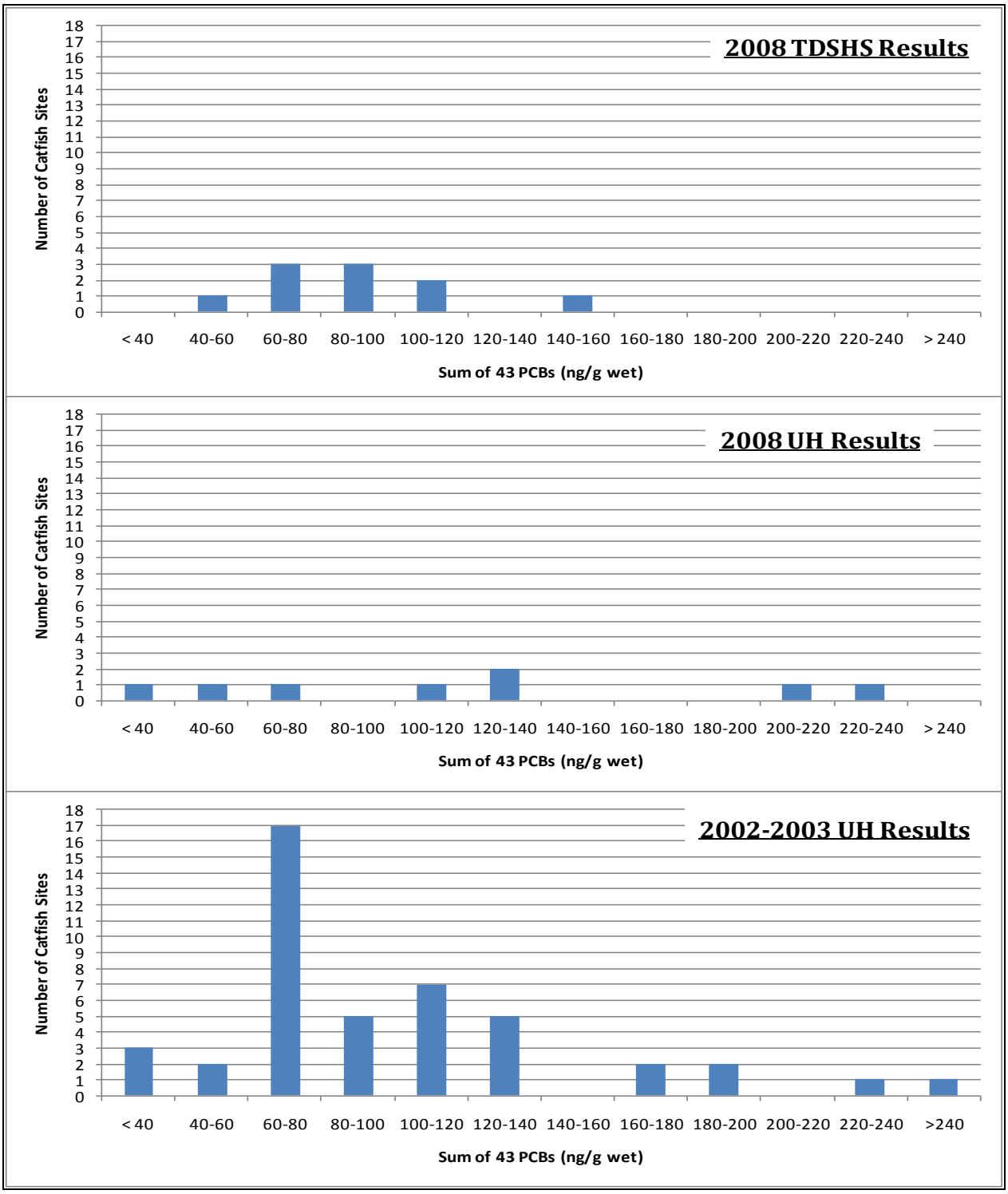
* All concentrations based on 1/2 detection limit treatment of non-detects and ∑43 congeners.

Figure 5.9a Comparison of Catfish PCB concentration between 2008 UH and 2008 TDSHS data



* All concentrations based on 1/2 detection limit treatment of non-detects and ∑43 congeners.

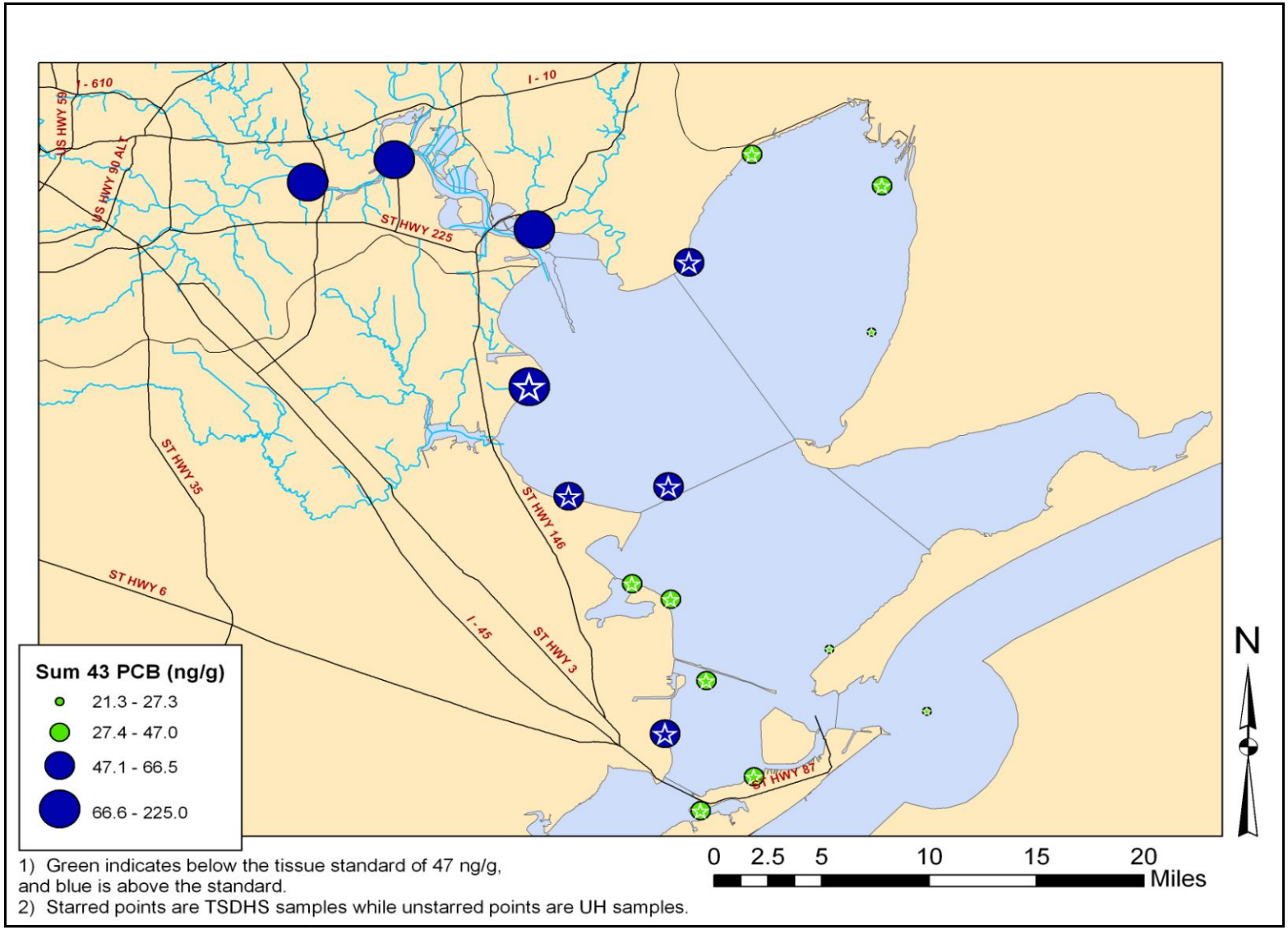
Figure 5.9b Comparison of Catfish PCB concentration between 2002-2003 UH and 2008 TDSHS data



* All concentrations based on 1/2 detection limit treatment of non-detects and ∑43 congeners.

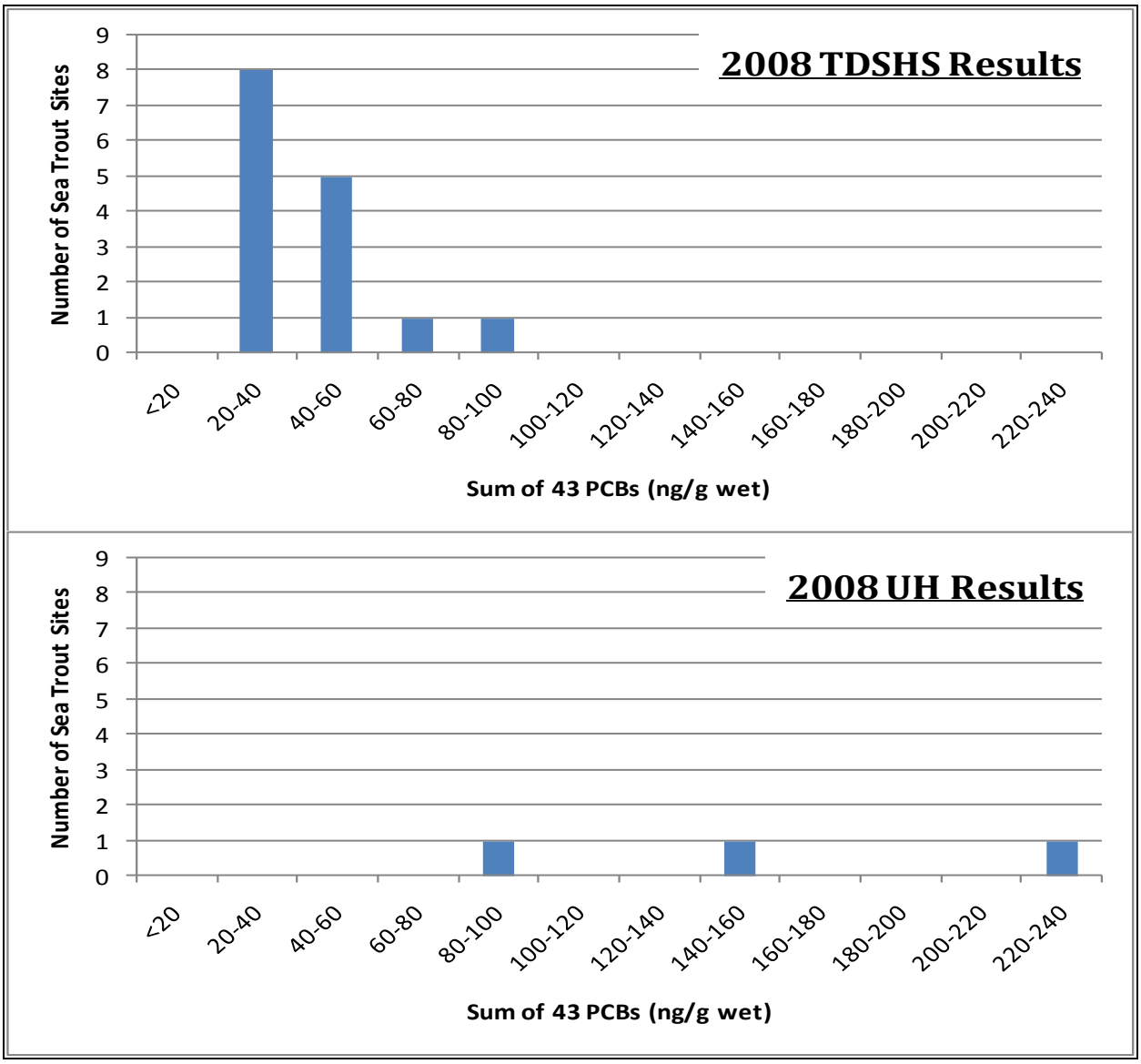
Figure 5.10 Comparison of PCB concentrations from 2008 TDSHS data, 2008 UH data, and 2002-2003 UH data in Catfish

Speckled seatrout were only compared between the newest 2008 UH PCB data and the 2008 TDSHS data because no speckled seatrout were caught and analyzed for PCBs in 2002-2003. Figure 5.11 compares the PCB concentrations in seatrout between 2008 UH data and 2008 TDSHS data. The map and histogram (Figure 5.12) show that trout concentrations in the HSC (those available) are definitively higher than what is in Galveston Bay. Only one site from Galveston Bay is comparable to trout caught in the HSC, and that is the same high concentration site found in Galveston Bay for catfish, Pine Gully. The majority of sites in Galveston Bay are below the tissue standard as was indicated in the TDSHS report.



* All concentrations based on 1/2 detection limit treatment of non-detects and ∑43 congeners.

Figure 5.11 Comparison of Seatrout PCB concentration between 2008 UH and 2008 TDSHS data



* All concentrations based on 1/2 detection limit treatment of non-detects and ∑43 congeners.

Figure 5.12 Comparison of PCB concentrations from 2008 TDSHS data and 2008 UH data in Speckled Seatrout

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APPENDIX A

Water Quality Parameters - FY 2008 Sampling

Station ID	Sample date	Total depth (ft)	Time	Sample collection depth (ft)	pH	Temperature (^{o}C)	Conductivity (mS/cm)	Salinity (ppt)
11132	5/13/08	3	10:22	1.5	8.13	26.51	0.88	0.93
			11:30	1.5	8.15	26.73	0.86	0.92
11139	5/13/08	0.6	16:43	0.3	8.53	27.20	0.81	0.39
			17:50	0.3	8.49	25.27	0.72	0.35
11171	4/24/08	0.1	10:45	0.1	9.26	26.54	0.33	0.16
			11:05	0.1	9.32	27.22	0.27	0.13
			13:25	0.1	10.12	30.87	0.67	0.32
			13:55	0.1	10.26	31.87	0.37	0.17
11193	5/1/08	7	17:10	1	7.81	23.47	12.65	7.27
			17:10	3	7.80	23.47	12.67	7.27
			17:10	5	7.80	23.47	12.63	7.25
11252	5/28/08	7	15:00	1	8.12	29.38	13.95	8.01
			15:00	3	8.06	26.59	14.82	8.58
			15:00	5	8.05	28.51	14.85	8.59
			16:25	1	8.10	29.30	14.18	8.15
			16:25	3	8.09	29.23	14.26	8.36
			16:25	5	8.07	28.68	15.27	8.84
11258	6/2/08	10	14:05	2	7.90	29.63	12.47	7.10
			14:05	5	7.84	29.41	12.58	7.17
			14:05	8	7.80	29.18	12.60	7.18
			14:55	2	7.90	29.60	12.34	7.01
			14:55	5	7.79	29.24	12.50	7.11
			14:55	8	7.76	29.19	12.54	7.14
			15:50	2	7.89	29.56	12.36	7.03
			15:50	5	7.86	29.46	12.40	7.06
			15:50	8	7.85	29.34	12.43	7.07
11261	6/4/08	16	8:56	2	7.86	29.13	10.90	6.15
		16	8:56	8	7.85	29.13	10.92	6.15
		16	8:56	14	7.85	29.14	11.00	6.20

Water Quality Parameters - FY 2008 Sampling

Station ID	Sample date	Total depth (ft)	Time	Sample collection depth (ft)	pH	Temperature (^{o}C)	Conductivity (mS/cm)	Salinity (ppt)
11261	6/4/08	16	10:00	2	7.83	29.02	11.36	6.45
		16	10:00	8	7.82	29.02	11.45	6.47
		16	10:00	14	7.84	29.02	11.55	6.48
		16	10:45	2	7.83	29.05	11.31	6.42
		16	10:45	8	7.85	29.03	11.44	6.49
		16	10:45	14	7.92	29.03	11.48	6.50
11262	6/4/08	12	16:10	2	7.88	29.35	11.08	6.25
		12	16:10	6	7.89	29.36	11.04	6.23
		12	16:10	10	7.91	29.38	11.05	6.23
		12	16:55	2	7.93	29.36	11.06	6.23
		12	16:55	6	7.94	29.36	11.06	6.24
		12	16:55	10	7.95	29.36	11.07	6.24
		12	17:50	2	7.96	29.36	10.90	6.14
		12	17:50	6	7.97	29.37	10.94	6.16
		12	17:50	10	7.98	29.37	11.00	6.20
11264	5/1/08	27	13:00	2	7.50	23.70	12.60	7.23
		27	13:00	12	7.50	23.60	12.67	7.26
		27	13:00	25	7.50	23.60	12.75	7.32
11270	4/29/08	6.5	16:00	1	7.42	24.82	8.22	4.57
		6.5	16:00	3	7.41	24.56	8.29	4.64
		6.5	16:00	5	7.49	23.88	9.21	5.14
		6.5	17:40	1	7.43	24.51	8.54	4.75
		6.5	17:40	3	7.42	24.45	8.59	4.76
		6.5	17:40	5	7.41	24.10	9.01	5.03
11274	4/29/08	10	11:40	1	7.38	24.01	3.52	1.84
		10	11:40	4.5	7.27	23.31	4.09	2.17
		10	11:40	8	7.23	23.48	4.45	2.37
		10	14:00	1	7.30	24.70	4.20	2.10
		10	14:00	4.5	7.09	23.75	5.08	2.73

Water Quality Parameters - FY 2008 Sampling

Station ID	Sample date	Total depth (ft)	Time	Sample collection depth (ft)	pH	Temperature (^{o}C)	Conductivity (mS/cm)	Salinity (ppt)
		10	14:00	8	7.05	23.75	5.47	2.95
11280	4/23/08	11.9	12:15	1.5	7.35	23.74	8.41	4.68
		11.9	12:15	5	7.35	23.43	8.49	4.73
11280	4/23/08	11.9	12:15	9	7.34	23.09	8.93	4.99
11287	4/21/08	14	14:43	1	7.39	24.65	4.11	2.15
		14	14:43	5	7.19	22.73	6.21	3.39
		14	14:43	11	7.19	22.56	6.30	3.45
11292	6/2/08	16.5	11:01	2	7.21	29.45	2.11	1.07
		16.5	11:01	8.5	7.14	28.81	2.30	1.16
		16.5	11:01	15	7.15	28.62	2.87	1.48
		16.5	11:35	2	7.27	29.64	2.13	1.08
		16.5	11:35	8.5	7.23	29.17	2.16	1.09
		16.5	11:35	15	7.21	28.61	3.00	1.55
		16.5	12:00	2	7.26	29.83	2.13	1.08
		16.5	12:00	8.5	7.19	28.93	2.20	1.11
		16.5	12:00	15	7.13	28.58	3.02	1.56
11347	5/21/08	2.5	10:35	1.25	7.65	27.53	0.73	0.35
		2.5	12:20	1.25	7.78	27.75	0.60	0.29
11368	5/14/08	3	11:15	1.5	7.77	25.63	0.67	0.33
		3	12:25	1.5	7.75	25.73	0.76	0.37
11387	5/12/08	2	11:44	1	8.45	24.53	0.46	0.22
13338	4/22/08	4.5	12:55	2.75	8.51	24.60	12.77	7.28
		4.5	12:58	1	8.52	24.69	12.67	7.27
		4.5	14:15	1	8.39	25.23	12.98	7.45
		4.5	14:15	2.5	8.35	25.22	12.95	7.43
		6.2	15:30	1	8.52	29.85	10.59	5.95
		6.2	15:30	2.5	8.52	29.84	10.60	5.95
		6.2	15:30	4	8.54	29.84	10.59	5.95

Water Quality Parameters - FY 2008 Sampling

Station ID	Sample date	Total depth (ft)	Time	Sample collection depth (ft)	pH	Temperature (^{o}C)	Conductivity (mS/cm)	Salinity (ppt)
13340	6/3/08	6.2	16:15	1	8.58	29.86	10.62	5.96
		6.2	16:15	2.5	8.58	29.86	10.62	5.96
		6.2	16:15	4	8.59	29.86	10.62	5.96
		6.2	17:00	1	8.55	29.97	10.66	5.99
13340	6/3/08	6.2	17:00	2.5	8.55	29.97	10.65	5.98
		6.2	17:00	4	8.56	29.97	10.66	5.99
		6.5	9:35	1	7.97	27.74	11.65	6.61
		6.5	9:35	3	7.97	27.75	11.67	6.62
		6.5	9:35	5	7.97	27.81	11.94	6.88
		6.5	10:17	1	7.63	27.90	11.71	6.65
13342	5/30/08	6.5	10:17	3	7.60	27.90	11.80	6.70
		6.5	10:17	5	7.66	27.88	12.08	6.88
		6.5	11:05	1	7.59	27.98	11.69	6.63
		6.5	11:05	3	7.57	28.00	11.73	6.66
		6.5	11:05	5	7.61	27.95	11.75	6.69
		8.5	10:40	1	8.25	28.67	11.50	6.51
		8.5	10:40	4	8.24	28.62	11.55	6.55
		8.5	10:40	7	8.21	28.52	11.72	6.63
		8.5	11:35	1	8.37	28.94	11.61	6.58
13344	6/3/08	8.5	11:35	4	8.37	28.92	11.59	6.56
		8.5	11:35	7	8.37	28.89	11.61	6.57
		8.5	12:50	1	8.19	28.86	11.06	6.24
		8.5	12:50	4	8.19	28.84	11.09	6.26
		8.5	12:50	7	8.19	28.84	11.09	6.26
		11.5	13:12	2	8.05	29.74	13.84	7.91
		11.5	13:12	6	8.07	29.62	13.94	8.01
		11.5	13:12	10	8.08	29.18	14.50	8.35
13355	5/29/08	11.5	14:19	2	8.08	30.02	13.82	7.92
		11.5	14:19	6	8.03	29.47	13.95	8.01

Water Quality Parameters - FY 2008 Sampling

Station ID	Sample date	Total depth (ft)	Time	Sample collection depth (ft)	pH	Temperature (^{o}C)	Conductivity (mS/cm)	Salinity (ppt)
		11.5	14:19	10	7.93	28.60	14.83	8.55
		11.5	15:05	2	8.01	29.18	14.32	8.24
		11.5	15:05	6	7.98	29.24	14.26	8.35
		11.5	15:05	10	7.96	28.89	14.60	8.40
13363	6/11/08	6	10:23	1	8.16	28.92	13.31	8.59
		6	10:23	4	8.10	28.79	15.32	8.94
13363	6/11/08	6	12:16	1	8.38	29.56	14.67	8.46
		6	12:16	4	8.08	28.97	15.69	9.11
		10.5	11:00	8	8.03	28.34	17.78	10.47
		10.5	12:48	1	8.43	28.95	12.80	7.30
		10.5	12:48	4	8.27	28.80	14.75	8.51
14560	5/28/08	10.5	12:48	8	8.10	28.42	16.53	9.69
		10.5	13:15	1	8.41	29.56	13.05	7.45
		10.5	13:15	4	8.21	28.65	15.50	9.02
		10.5	13:15	8	8.09	28.40	17.07	9.91
		6.5	12:25	2	7.86	29.10	5.25	9.44
15301	6/4/08	6.5	12:25	4	7.94	29.09	5.26	9.45
		6.5	14:14	2	7.89	29.35	9.59	5.33
		6.5	14:14	4	7.93	29.34	9.68	5.36
		7	11:45	1	7.55	23.84	10.93	6.20
		7	11:45	3.5	7.40	23.59	11.13	6.32
		7	11:45	5	7.07	23.61	11.13	6.32
		7	12:45	1	7.61	24.07	11.03	6.26
15936	4/30/08	7	12:45	1	7.61	24.07	11.03	6.26
		7	12:45	3.5	7.58	23.83	11.05	6.28
		7	12:45	3.5	7.58	23.83	11.05	6.28
		7	12:45	5	7.45	23.58	11.55	6.59
		7	12:45	5	7.45	23.58	11.55	6.59
15979	4/30/08	3.5	16:15	1.5	7.60	24.23	10.22	5.77

Water Quality Parameters - FY 2008 Sampling

Station ID	Sample date	Total depth (ft)	Time	Sample collection depth (ft)	pH	Temperature (^{o}C)	Conductivity (mS/cm)	Salinity (ppt)
		3.5	17:30	1.5	7.50	24.03	10.98	6.23
		3.5	17:30	1.5	7.50	24.03	10.98	6.23
16213	5/27/08	10.5	11:11	1	8.22	28.21	18.17	10.69
		10.5	11:11	5	8.21	28.19	18.17	10.69
		10.5	11:11	8	8.20	28.16	18.21	10.71
		10.5	12:46	1	8.25	28.49	18.17	10.69
		10.5	12:46	5	8.22	28.34	18.16	10.68
		10.5	12:46	8	8.21	28.25	18.19	10.72
16499	5/29/08	3.5	9:35	0.5	7.70	29.22	12.05	6.80
		3.5	9:37	2	7.74	29.21	11.99	6.81
		3.5	10:30	0.5	7.76	29.61	11.40	6.45
		3.5	10:30	2	7.73	29.44	12.08	6.86
		3.5	11:30	0.5	7.80	30.02	11.50	6.50
		3.5	11:30	2	7.72	29.47	11.99	6.81
16618	5/30/08	4.5	13:25	2.5	7.81	28.23	13.51	7.75
		4.5	14:28	2.5	7.79	29.00	13.37	7.66
		4.5	15:36	2.5	7.82	28.94	13.59	7.79
16622	5/2/08	6	10:22	1	8.11	24.00	2.00	1.02
		6	10:22	3	8.08	24.00	2.02	1.05
		6	10:22	4	8.08	24.00	2.06	1.06
		14	11:25	1	8.26	24.17	1.70	0.85
		14	11:25	4	8.20	24.08	1.74	0.88
		14	11:25	8	8.10	24.03	1.84	0.94
		14	12:55	1	8.37	24.27	1.35	0.68
		14	12:55	4	8.33	24.23	1.35	0.68
		14	12:55	8	8.30	24.19	1.42	0.71
16657	6/20/08	1.3	9:43	1	7.83	27.86	0.51	0.24
		1.3	10:41	1	7.77	28.18	0.43	0.21
		1.3	11:41	1	7.82	28.73	0.51	0.24

Water Quality Parameters - FY 2008 Sampling

Station ID	Sample date	Total depth (ft)	Time	Sample collection depth (ft)	pH	Temperature (^{o}C)	Conductivity (mS/cm)	Salinity (ppt)
17149	7/29/08	3	10:08	0.67	8.01	24.00	13.48	7.77
		3	12:27	0.67	7.91	23.73	13.94	7.91
TBD2	5/15/08	2	12:01	1	7.53	25.87	2.81	1.45
		2	13:18	1	7.58	26.22	2.17	1.11
TBD5	5/12/08	3	18:15	1.5	7.72	25.43	0.20	0.08
TBD6	5/14/08	0.5	16:54	0.25	7.66	25.05	1.24	0.58
		0.5	18:17	0.25	7.73	25.18	0.94	0.44
TBD7	5/15/08	2	17:02	1	7.94	29.68	0.46	0.24
		2	18:30	1	8.06	29.78	0.48	0.23