Appendix F. Water Quality Data

Assessment Methodology

To assess the current state of the watershed, 1998-2003 water quality data were analyzed, primarily from the Texas Commission on Environmental Quality (TCEQ) database, which includes data collected by state agencies, river authorities, county and local governments and volunteer citizen monitors. From the data set, the following key parameters were chosen for this watershed analysis:

- Salinity
- Dissolved oxygen
- Chlorophyll-a
- Nutrients
- Fecal coliform bacteria
- Water clarity (turbidity)
- Sediment chemistry
- Fish kill data

The water quality data were partitioned into seven distinct reaches of Armand Bayou. Four are on the mainstem:

- Mud Lake (the lower tidal reach downstream of the confluence with Horsepen Bayou to the Nasa Parkway bridge)
- Middle Tidal (from the confluence with Horsepen Bayou to the confluence with Big Island Slough, including Bay Area Boulevard and Bay Area Park)
- Upper Tidal (near Oil Field Road)
- Above Tidal (near Genoa-Red Bluff Road)

The other three reaches represent major tributaries:

- Spring Gully
- Big Island Slough
- Horsepen Bayou

Because the data was not consistently collected in all reaches of the bayou or for all parameters of interest, the number of samples available for analysis is indicated for each parameter and reach. The only data available for Spring Gully since 1998 are a few samples from the special study in 1999, so it is not included in the discussions. In addition to this compilation of current data, the entire period of record was analyzed to see if any discernable trends could be identified in the individual reaches for the parameters considered.

Salinity

Salinity is the measure of the amount of dissolved salts in a solution. Salinity is usually determined indirectly by measuring a physical property such as electrical conductivity, which is the ability of a solution to carry an electrical current, and is measured in µmhos/cm. The salt content of freshwater is generally described in terms of its conductivity, which is usually less than 1000 µmhos/cm. Salt water is usually described in terms of its salinity. Salinity is less than 1 part per thousand (ppt) in fresh water and about 35 ppt in the Gulf of Mexico.

The average surface salinity for Mud Lake was 6.7 ppt and it was 2.0 ppt for the Middle Tidal reach. Maximum surface salinities for these two areas reached 20.6 ppt and 12.2 ppt for Mud Lake and Middle Tidal, respectively. Surface waters in the Upper Tidal and above tidal areas had variable conductivity values below 800 µmhos/cm, which is normal for freshwater streams. Big Island Slough and Horsepen Bayou had conductivity values indicating periods of freshwater up to one sample in Horsepen Bayou with a conductivity of 9600 µmhos/cm, which corresponds to a salinity of 5.5 ppt. (Table 1) Essentially, the data show that Armand Bayou is a freshwater to low salinity system.

Dissolved Oxygen

At normal saturation levels, the concentration of dissolved oxygen in Galveston Bay is between 7 and 9 mg/L, depending on water temperature and salinity. Several factors can change the dissolved oxygen levels, however. If excess algal growth occurs, very high dissolved oxygen concentrations (up to 15 or even 20 mg/L) may result. This happens when a great deal of photosynthesis takes place in the water, typically in sunny, warm conditions with high concentrations of nutrients that will allow excess algal growth.

Table 1. Surface (0.3 m depth) conductivity and salinity data from Armand Bayou from 1998 to 2003, where n is the number of measurements

		Specific Conductance (µmhos/cm)				Salinity (ppt)			
	Reach	Avg	n	min	max	Avg	n	min	max
1	Mud Lake	11030	35	372	32800	6.7	34	0.8	20.6
2	Middle Tidal	2669	63	154	20300	2.0	33	0.2	12.2
3	Upper Tidal	424	6	327	544	0.4	5	0.2	1.0
4	Above Tidal	506	27	100	800				
6	Big Island Slough	987	3	503	1940				
7	Horsepen Bayou	1777	79	158	9600				

Conversely, much lower dissolved oxygen levels can occur if there is high oxygen demand (e.g. unusually high numbers of organisms and algae) in the water. If the dissolved oxygen becomes very low (e.g. < 2 mg/L), then many aquatic organisms will not be able to survive. One instance where dissolved oxygen levels may become very low in a water body is at night if an algal bloom occurs, because the algae and the fish that feed on them are still using oxygen at night when no photosynthesis takes place. With their high daytime production and high nighttime oxygen demand, algal blooms cause a large diurnal swing in dissolved oxygen. In some cases these dissolved oxygen swings can be extreme enough to cause large fish kills.

In estuarine tributaries, the water is generally stratified, or layered, meaning that the deeper waters and the shallow waters are not well mixed. Much of this stratification is due to salinity, because high salinity water is heavier than lower salinity water. When possible, dissolved oxygen is measured at the surface (0.3 meters) and at various depths in the water column because significant differences in dissolved oxygen levels may occur at different depths if the layers are not well mixed. If the water is very shallow or if a dissolved oxygen meter with a cable is not available, the dissolved oxygen will just be measured at the 0.3-meter depth. To present this data on Armand Bayou, the surface (0.3 m) samples were compiled separately because they were available for each sampling event and they can be compared directly to one another. The limited data available on the deeper layers of the water column was compiled separately and is shown in the following table in the row below the surface data. The deeper parts of the water column generally had lower dissolved oxygen levels than the surface.

Overall, dissolved oxygen was lowest in the Upper Tidal reach, averaging 4.4 mg/L at the surface and 3.5 mg/L in the profile measurements (Table 2). Three of the six surface readings and nine of the 14 profile readings were below 4 mg/L, which is the TCEQ water quality standard for this segment. (Two of those nine profile readings would have been excluded from assessment based on temperature stratification.) The limited 24-hour monitoring (from continuously recording meters deployed overnight) also shows that this area has chronically low dissolved oxygen in the warmer months.

Oxygen levels in Mud Lake, Horsepen Bayou, and the Middle Tidal reaches were generally high, with only a few surface readings that fell below 4 mg/L (4% in Horsepen and Middle Tidal). The 24-hour monitoring also shows this pattern in the middle and lower tidal reaches.

Chlorophyll-a

Chlorophyll-a is typically used to measure the relative levels of phytoplankton in the water. Pheophytin-a is also sometimes measured, as it is "recently dead" chlorophyll. Sometimes the combination of these values is a better measure of the overall trophic condition (ability to support the food web) of a water body.

Average chlorophyll values were highest in Mud Lake, Middle Tidal, and Horsepen Bayou reaches, where the dissolved oxygen levels were also very high (Table 3). In the trend analysis, it appears that overall chlorophyll-a is decreasing, while pheophytin-a is increasing, however in the Mud Lake reach both chlorophyll and pheophytin may be increasing. Declines in chlorophyll-a are observed in many other areas of the Galveston Bay system as well. Effects of the declining chlorophyll-a concentrations on higher levels of the food chain are not yet known. Increases in chlorophyll-a appear to occur only in areas identified as eutrophic.

Table 2. Dissolved oxygen readings from Armand Bayou from 1998 – 2003, where n is the number of measurements

Reach		Dissolved Oxygen (mg/L)							
(depth of samples)		Avg	n	min	max	Below 4 mg/L		Above 10 mg/L	
1	Mud Lake (0.3 m)	8.6	35	5.1	14.8	0	0%	7	20%
	Mud Lake (0.6 - 2.1 m)	7.2	16	4.9	10.0	0	0%		
2	Middle Tidal	8.8	82	3.0	21.6	3	4%	23	28%
	Bay Area Blvd (1.1 - 2.7 m)	6.1	33	0.2	13.1	7	21%	0	0%
3	Upper Tidal	4.4	6	2.5	7.9	3	50%	0	0%
	Upper Tidal (0.6 - 3.0 m)	3.5	14	0.9	7.6	9	64%		
4	Above Tidal	6.2	38	3.3	9.1	7	18%	0	0%
6	Big Island Slough	8.1	3	7.2	8.6	0	0%	0	0%
	Big Island Slough (0.6 - 1.5 m)	6.1	3	4.9	7.1	0	0%	0	0%
7	Horsepen Bayou	7.8	99	2.5	15.0	4	4%	20	20%
	Horsepen Bayou (0.9 - 2.7 m)	6.0	9	0.5	12.2	3	33%	0	0%

Nutrients

Total phosphorus and ammonia values tended to be highest in Horsepen Bayou, while Mud Lake and Middle Tidal had relatively high phosphorus concentrations (Table 4). Average ammonia was generally low in the other reaches.

Fecal Coliform Bacteria

Based upon the screening level, fecal coliform bacteria counts were high in about 20% of the samples considered here, with no obvious differences between the reaches (Table 5). Table 5 presents fecal coliform data from Armand Bayou (1998 - 2003) compared to the TCEQ water quality screening level. The current assessment guidance lists a waterbody as impaired for bacteria if >25% of the samples exceed the screening level.

Water Clarity (Turbidity)

Water clarity averaged a little lower in the Mud Lake and Middle Tidal reaches than the other reaches (Table 6). Total suspended solids were also highest in Mud Lake and Middle Tidal. The trend analysis indicated that water clarity (secchi depth) in Horsepen Bayou appears to have shown some improvement from 1990 to the present.

Sediment Contaminants

Sediment was sampled for metals only twice in 2002 by the TCEQ. Copper, cadmium, mercury, zinc, lead and arsenic did not exceed any state screening levels. However, chromium and nickel slightly exceeded the state 85th percentile at the Middle Tidal station in one of the two samples. Barium exceeded the state 85th percentile at the Upper Tidal station in both of the samples. The 85th percentile is a value computed from the TCEQ database that is higher than 85% of the samples collected from tidal streams. A sample that exceeds the this number is relatively high but will not necessarily cause adverse effects. While nickel, chromium and barium exceeded the 85th percentile, they did not exceed any effects-based screening levels.

Fish Kill Data

TPWD maintains an inventory of fish kills and pollution complaints in its Pollution Response Inventory and Species Mortality (PRISM), with records existing as early as the 1970's. (Records from the 1970's and early 1980's may be incomplete.) Fish Kill and pollution events in the Armand Bayou watershed are investigated by staff from TPWD's Dickinson office, often in collaboration with TCEQ staff.

TPWD records indicated that seven fish kills have been recorded in the Armand Bayou watershed since 1971.

Table 3. Chlorophyll-a and pheophytin a values from Armand Bayou (1998-2003), where n is the number of measurements.

		Chlorophyll-a (µg/L)				Chlorophyll-a + Pheophytin a			
	Reach	Avg	n	min	max	Avg	n	min	max
1	Mud Lake	38.3	24	1	135	77.7	24	8.4	344.0
2	Middle Tidal	27.3	28	1	69.4	58.0	28	6.9	189.4
3	Upper Tidal	10.5	7	1	26	33.7	7	13.1	57.4
4	Above Tidal		0						
6	Big Island Slough	9.2	5	1	25.8	33.8	5	5.0	94.8
7	Horsepen Bayou	23.7	12	1	79.2	46.8	12	4.2	101.5

Table 4. Ammonia and phosphorus concentrations in Armand Bayou (1998 - 2003), where n is the number of measurements.

		Ammonia (mg/L)				Phosphorus (mg/L)			
	Reach	Avg	n	min	max	Avg	n	Min	max
1	Mud Lake	0.08	23	0.05	0.26	0.43	23	0.21	0.78
2	Middle Tidal	0.11	55	0.01	0.64	0.42	33	0.15	0.90
3	Upper Tidal	0.09	11	0.01	0.17	0.18	11	0.07	0.35
4	Above Tidal	0.12	11	0.01	0.35	0.19	5	0.10	0.40
5	Spring Gully	0.11	5	0.01	0.19	0.05	5	0.01	0.11
6	Big Island Slough	0.07	5	0.05	0.15	0.24	5	0.21	0.30
7	Horsepen Bayou	0.26	74	0.01	2.28	1.37	19	0.24	4.20

Table 5. Fecal Coliform values in Armand Bayou (1998 - 2003)

		Fecal Coliform, cfu/100ml				(Screening Level 400 cfu/100mL)	
	Reach	Average	N	Minimum	Maximum	# Exceeds	% Exceeds
1	Mud Lake	1167	32	10	30500	5	16%
2	Middle Tidal	1162	42	9	34000	9	21%
3	Upper Tidal	226	4	18	490	1	25%
4	Above Tidal	4023	2	45	8000	1	50%
6	Big Island Slough	50	2	27	72	0	0%
7	Horsepen Bayou	995	40	10	12000	10	25%

Table 6. Secchi and total suspended solids (TSS) data for Armand Bayou (1998 - 2003)

		Secchi (meters)				TSS (mg/L)			
	Reach	Avg	n	min	max	Avg	n	min	max
1	Mud Lake	0.34	31	0.15	0.7	45	24	19	99
2	Middle Tidal	0.32	50	0.15	3.5	36	42	4	90
3	Upper Tidal	0.55	4	0.2	1.02	21	6	12	35
4	Above Tidal	0.52	32	0.2	0.8	11	7	4	22
6	Big Island Slough	0.48	3	0.4	0.52				
7	Horsepen Bayou	0.54	29	0.2	1.15	16	81	1	62

Table 7. Historical fish kills in the Armand Bayou watershed

Start Date	Exact Location Name	Est. Total Killed	Cause	Event Description
4-20-71	Middle Bayou (Armand Bayou) from Bay Area Blvd. to Spring Gully.	500	Low Dissolved Oxygen	Approximately 500 fish were found dead in Middle Bayou (Armand Bayou).
7-30-79	Big Island Slough - One half mile East and one-half mile West of Red Bluff	352	Low Dissolved Oxygen	Fish kill in Big Island Slough, Harris County.
10-16-81	Drainage ditch in Brookforest subdivision — where ditch enters Horsepen Bayou	204	Low Dissolved Oxygen	Two hundred and four fish were killed in a drainage ditch in Brookforest subdivision.
01-25-97	Armand Bayou between Bay Area (above) and the golf course (below).	210	Cold front / freeze	An estimated 200 gar, less than 10 catfish, and some sunfish were observed dead in Armand Bayou, Harris County, Texas.
02-06-97	Drainage ditch that goes into Horsepen Bayou at Brook Forest Subdivision.	157	Unknown	
12-12-97	Spencer Highway and Big Island Slough	19,568	Gasoline	A spill of unleaded gasoline into Big Island Slough caused a fish kill of sunfish, largemouth bass, bullhead catfish, striped mullet, blue crab, crayfish, and minnows.
05-20-99	Willow Spring Creek downstream of Pasadena Blvd. to Canada Street.	182	Low Dissolved Oxygen	A fish kill occurred in Willow Spring creek due to low dissolved oxygen.

Appendix G. HCFCD Stream Designations

The Harris County Flood Control District uses a channel numbering system developed in 1945 to identify and catalog channels. The system utilizes a combination of letters and numbers, and does not reflect ownership by any public entity or identify property rights or maintenance responsibility.

Several channels and detention basins in the Armand Bayou watershed are known by local names. Some of these include:

Stream / Basin Name	HCFCD Number
Armand Bayou	B100-00-00
Horsepen Bayou	B104-00-00
Big Island Slough	B106-00-00
Spring Gully	B109-00-00
Willow Springs Bayou	B112-00-00
Spencer Highway Basin	B500-01-00
Fairmont Parkway Basin	B500-02-00
Red Bluff Road Basin	B500-04-00
Underwood Road Basin	B512-01-00
Baywood Basin	B513-02-00
Anthony Road Basin	B513-03-00

PHOTO BY STEPHAN MYERS

Appendix H. Basic Stream Facts

Reach/Location	Key Map	Description of Channel	Length (Ft.)	Detention Acreage
B100-00-00 (Armand Bayou)				
Clear Creek to NASA Partkway	619 QP	Natural Earthen Channel Section	2,521	
NASA Parkway to B101-00	619 PK	Natural Earthen Channel Section	2,950	
B101-00 to B104-00	619 KFB	Natural Earthen Channel Section	9,001	
B104-00 to Bay Area Blvd.	619 BA	Natural Earthen Channel Section	5,597	
Bay Area Blvd. to B106-00	619 A, 579 W	Natural Earthen Channel Section	1,172	
B106-00 to B105-00	579 W	Natural Earthen Channel Section	2,916	
B105-00 to B107-00	579 W	Natural Earthen Channel Section	3,147	
B107-00 to B108-00	579 WS, 578 V	Natural Earthen Channel Section	5,118	
B108-00 to B109-00	578 V	Natural Earthen Channel Section	2,859	
B109-00 to B110-00	578 R	Natural Earthen Channel Section	5,669	
B110-00 to B111-00	578 RQ	Natural Earthen Channel Section	6,199	
B111-00 to Genoa-Red Bluff Rd.	578 QL	Natural Earthen Channel Section	2,177	
Genoa-Red Bluff Rd. to B112-00	578 L	Natural Earthen Channel Section	2,098	
B112-00 to B113-00	578 L	Natural Earthen Channel Section	1,114	
B113-00 to B116-00	578 LGF	Natural Earthen Channel Section	3,763	
B116-00 to Fairmont Pkwy	578 F	Natural Earthen Channel Section	2,185	
Fairmont Pkwy to B115-00	578 FB	Natural Earthen Channel Section, Includes B500-02	3,684	
B115-00 to B114-00	578 FBA	Natural Earthen Channel Section, Includes B500-04	1,650	
B114-00 to Trebor Street	538 W, 578A	Natural Earthen Channel Section	1,281	
Trebor Street to B117-00	538 W	Natural Earthen Channel Section	1,641	
B117-00 to Spencer Highway	537 Z	Natural Earthen Channel Section, Includes B500-01	1,760	
Spencer Highway to Beltway 8	537 Z	Manmade Earthen Channel Section	2,092	
Beltway 8 to Pansy Street	537 ZY	Manmade Earthen Channel Section	2,566	
B101-00-00 (Cow Bayou)				
B100-00 to Space Center Blvd.	619 K	Manmade Earthen Channel Section	3,662	
B104-00-00 (Horsepen Bayou)				
B100-00 to B104-11	619 BAE	Natural Earthen Channel Section	2,989	
B104-11 to B104-01	619 E, 618 H	Natural Earthen Channel Section	4,811	
B104-01 to Bay Area Blvd	618 H	Natural Earthen Channel Section	3,076	
Bay Area Blvd. to B104-02	618 H	Natural Earthen Channel Section	1,062	
B104-02 to B104-08	618 HG	Natural Earthen Channel Section	1,376	
B104-08 to El Dorado Blvd.	618 G	Natural Earthen Channel Section	2,698	
El Dorado to B104-03	618 GF	Natural Earthen Channel Section	1,315	
B104-03 to B104-04	618 FB	Natural Earthen Channel Section	3,488	
B104-04 to B204-04	618 BA	Natural Earthen Channel Section	3,327	
B204-04 to B104-10	618 A	Natural Earthen Channel Section	1,541	
B104-10 to B104-05	618 A, 617 D	Natural Earthen Channel Section	1,457	
B104-05 to B104-06	617 D	Natural Earthen Channel Section, Adjacent to B504-04	2,412	

Reach/Location	Key Map	Description of Channel	Length (Ft.)	Detention Acreage
B104-06 to B104-09	617 DC	Natural Earthen Channel Section	4,599	
B104-09 to Upstream End	617 CB	Manmade Earthen Channel Section	4,208	
B104-01-00				
B104-00 to Space Center Blvd.	618 HM	Manmade Earthen Channel Section	2,186	
Space Center to Saturn Lane	618 MR	Manmade Earthen Channel Section	6,347	
B104-02-00				
B104-00 to Space Center Blvd.	618 HGL	Manmade Earthen Channel Section	4,909	
Space Center Blvd. to Neptune Lane	618 L	Manmade Earthen Channel Section	1,487	
Neptune Lane to Reseda Lane	618 L	Manmade Earthen Channel Section	2,242	
Reseda Lane to Upstream End	618 LQ	Manmade Earthen Channel Section	461	
B104-03-00				
B104-00 to B104-03-01	618 F	Natural Earthen Channel Section	1,279	
B104-03-01 to Space Center Blvd.	618 F	Manmade Earthen Channel Section	1,713	
Space Center Blvd. to Penn Hills Lane	618 F	Manmade Earthen Channel Section	1,138	
Penn Hills Lane to B104-03-02	618 FK	Manmade Earthen Channel Section	1,566	
B104-03-02 to El Dorado Blvd.	618 K	Manmade Earthen Channel Section	1,934	
El Dorado Blvd. to Reseda Drive	618 KP	No channel--Replaced by storm sewer	2,793	
B104-03-01				
B104-03 to Space Center Blvd.	618 F	Manmade Earthen Channel Section	1,657	
B104-03-02				
B104-03 to El Camino Real	618 KJ	Manmade Earthen Channel Section	1,945	
El Camino Real to Pebbleshire Drive	618 J	Manmade Earthen Channel Section	2,091	
Pebbleshire Drive to B104-03-02.1	618 JN	Manmade Earthen Channel Section	961	
B104-03-02.1				
B104-03-02 to B104-03-02.1A	618 N	Manmade Earthen Channel Section	2,066	
B104-03-02.1A to Buoy Road	618 N	Manmade Earthen Channel Section	2,098	
Buoy Rd. to El Toro Road	618 N	Manmade Earthen Channel Section	1,409	
El Toro to Elder Glen Dr.	618 NS	Manmade Earthen Channel Section	2,391	
B104-03-02.1A				
B104-03-02 to Barringer Lane	618 N, 617 RM	Manmade Concrete Lined Channel Section	1,769	
B104-04-00				
B104-00 to Clear Lake City Blvd.	618 B, 578 X	Manmade Earthen Channel Section	3,901	
Clear Lake City Blvd. to Private Road	578 XWS	Manmade Earthen Channel Section, Adjacent to B504-01 and B502-02	9,769	
Private Road to B104-04-02	578 SN	Manmade Earthen Channel Section	1,893	
B104-04-02 to B104-04-04	578 N, 577 R	Manmade Earthen Channel Section	4,527	
B104-04-04 to B111-05	577 RQ	Manmade Earthen Channel Section	1,777	
B111-05 to B111-04	577 Q	Manmade Earthen Channel Section	820	
B111-04 to B104-04-06	577 Q	Manmade Earthen Channel Section	1,987	
B104-04-02				
B104-04 to Genoa-Red Bluff	578 NJ	Manmade Earthen Channel Section	3,108	
B104-04-04				
B104-04 to Genoa-Red Bluff	577 RM	Manmade Earthen Channel Section	1,378	
B104-04-06				
B104-04 to Beltway 8	577 Q	Manmade Earthen Channel Section	1,311	

Reach/Location	Key Map	Description of Channel	Length (Ft.)	Detention Acreage
B104-05-00				
B104-00 to B104-05-01	617 DH	Natural Earthen Channel Section	3,386	
B104-05-01 to GH&H Railroad	617 HG	Natural Earthen Channel Section	2,649	
B104-05-01				
B104-05 to Clear Lake City Blvd.	617 H	Manmade Earthen Channel Section	1,206	
Clear Lake City Blvd. to Crescent Landing	617 H	Natural Earthen Channel Section	1,515	
Crescent Landing to Upstream End	617 H	Manmade Earthen Channel Section	1,024	
B104-06-00				
B104-00 to u/s end	617 D, 577 Z	Manmade Earthen Channel Section	5,298	
B104-08-00				
B104-00 to Hickory Knoll Drive	618 GC	Manmade Earthen Channel Section	3,804	
Hickory Knoll to Upstream End	618 C, 578 Y	Manmade Earthen Channel Section	2,082	
B104-09-00				
B104-00 to u/s end	617 C	Manmade Earthen Channel Section	1,643	
B104-10-00				
B104-00 to Clear Lake City Blvd.	618 A	Manmade Earthen Channel Section	1,123	
Clear Lake City Blvd. to Upstream End	618 AE	Manmade Earthen Channel Section	3,369	
B104-11-00				
B104-00 to Middlebrook Dr.	619 A	Natural Earthen Channel Section	2,629	
B105-00-00				
B100-00 to upstream end	579 W, 578 Z	Manmade Earthen Channel Section	2,711	
B106-00-00 (Big Island Slough)				
B100-00 to Red Bluff Road	579 WS	Natural Earthen Channel Section	6,166	
Red Bluff Road to Fairmont Parkway	579 TPKF	Natural Earthen Channel Section	15,873	
Fairmont Parkway to B106-02	579 FB	Natural Earthen Channel Section	2,000	
B106-02 to Spencer Highway	579 B, 539X	Natural Earthen Channel Section	2,831	
Spencer Highway to North H Street	539 XT	Natural Earthen Channel Section	3,754	
North H Street to B106-05	359 T	Natural Earthen Channel Section	1,710	
B106-05 to B106-06	539 T	Natural Earthen Channel Section	513	
B106-06 to North P Street	539 TP	Natural Earthen Channel Section	2,099	
North P Street to Railroad	539 PK	Natural Earthen Channel Section	4,809	
B106-02-00				
B106-00 to Old Hickory Drive	579 BC	Manmade Earthen Channel Section	2,234	
Old Hickory Dr. to Driftwood Drive	579 C	Manmade Earthen Channel Section	2,659	
B106-05-00				
B106-00 to North P Street	539 TP	Manmade Earthen Channel Section	2,573	
North P Street to Upstream End	539 P	Manmade Earthen Channel Section	1,872	
B106-06-00				
B106-00 to North P Street	539 TP	Natural Earthen Channel Section	1,673	
North P Street to Upstream End	539 P	Manmade Earthen Channel Section	1,422	
B107-00-00				
B100-00 to Clear Lake City Blvd.	579 W, 578 Z	Natural Earthen Channel Section	4,994	
Clear Lake City Blvd. to Upstream End	578 ZV	Manmade Earthen Channel Section	1,753	

Reach/Location	Key Map	Description of Channel	Length (Ft.)	Detention Acreage
B108-00-00				
B100-00 to upstream end	578 VUT	Manmade Earthen Channel Section	10,086	
B109-00-00 (Spring Gully)				
B100-00 to Red Bluff Road	579 SN	Natural Earthen Channel Section	1,191	
Red Bluff Road to Fairmont Parkway	579 NJE	Natural Earthen Channel Section	11,393	
Fairmont Parkway to B109-03	579 EA	Natural Earthen Channel Section	2,577	
B109-03 to Carlow Street	579 A	Manmade Earthen Channel Section	2,272	
Carlow Street to Andricks	579 A	Manmade Earthen Channel Section	1,354	
B109-03-00				
B109-00 to confluence w/ B112-02	579 A, 578 D	Manmade Earthen Channel Section	1,754	
B110-00-00				
B100-00 to upstream end	578 RQP	Manmade Earthen Channel Section	6,945	
B111-00-00				
B100-00 to Spurgem	578 Q	Natural Earthen Channel Section	1,995	
Spurgem to B111-02	578 QP	Natural Earthen Channel Section	2,155	
B111-02 to Upstream End	578 PN, 577 RQ	Manmade Earthen Channel Section	6,865	
B111-06 to Beltway 8	577 QP	No channel--stormsewer outfalls `into realigned B104-04	4,275	
B111-01-00				
B111-00 to Private Road	578 Q	Manmade Earthen Channel Section	797	
Private Road to Upstream End	578 Q	Manmade Earthen Channel Section	921	
B111-02-00				
B111-00 to Genoa Red Bluff Road	578 K	Manmade Earthen Channel Section	1,749	
B111-04-00				
B104-04 to upstream end	577 Q	No channel--Replaced by storm sewer	873	
B111-05-00				
B104-04 to Genoa Red Bluff Road	577 Q	No channel--Replaced by storm sewer	1,348	
B111-06-00				
Beltway 8 to Upstream End	577 L	Manmade Concrete Lined Channel Section	1,774	
B112-00-00 (Willowsprings Bayou)				
B100-00 to B112-01	578 LG	Natural Earthen Channel Section	1,314	
B112-01 to B112-05	578 G	Natural Earthen Channel Section	4,160	
B115-05 to Chattanooga Street	578 GCD	Natural Earthen Channel Section	2,249	
Chattanooga Street to B112-02	578 D	Natural Earthen Channel Section	1,840	
B112-02 to Spencer Highway	578 D, 538 Z	Concrete Lined Natural Channel Section	1,315	
Spencer Highway to B112-03	538 Z	Manmade Concrete Lined Channel Section	4,304	
B112-03 to B112-04	538 ZV	Manmade Concrete Lined Channel Section	1,330	
B112-04 to Luella Avenue	538 U	Manmade Concrete Lined Channel Section	1,189	
Luella Ave. to Pasadena Blvd.	538 U	Manmade Concrete Lined Channel Section	1,403	
Pasadena Blvd. to Eileen Street	538 U	Manmade Concrete Lined Channel Section	1,570	
Eileen Street to B112-06	538 U	Manmade Concrete Lined Channel Section	686	
B112-06 to Center Street	538 UT	Manmade Concrete Lined Channel Section	1,230	

Reach/Location	Key Map	Description of Channel	Length (Ft.)	Detention Acreage
B112-01-00				
B112-00 to Fairmont Parkway	578 G	Manmade earthen roadside ditch in Red Bluff Road right-of-way.	3,709	
B112-02-00				
B112-00 to Plantation Street	578 D	Manmade Concrete Lined Channel Section	1,822	
Plantation to Canada Street	578 D	Manmade Earthen Channel Section	692	
Canada Street to Spencer Hwy	578 D, 538Z	Manmade Earthen Channel Section	1,529	
Spencer Hwy to south side B512-01	539 W	Manmade Earthen Channel Section	2,114	
Through B512-01	539 W	Manmade Earthen Channel Section	2,081	
North side B512-01 to Pasadena Blvd.	539 WS	Manmade Earthen Channel Section	1,910	
Pasadena Blvd. to North P Street	539 WSN	Manmade Earthen Channel Section	1,875	
North P Street to Upstream End	539 NJ	Manmade Earthen Channel Section	5,599	
B112-03-00				
B112-00 to B112-03-01	538 ZYX	Manmade Concrete Lined Channel Section	1,466	
B112-03-01 to Center Street	538 ZYX	Manmade Concrete Lined Channel Section	3,011	
B112-03-01				
B112-03 to East Lambuth Lane	538 Y	Manmade Concrete Lined Channel Section	1,330	
East Lambuth Lane to Upstream End	638 Y	Manmade Concrete Lined Channel Section	1,427	
B112-04-00				
B112-00 to West Pasadena Blvd.	538 V	Manmade Concrete Lined Channel Section	953	
West Pasadena Blvd. to East P Street	538 VU	Manmade Concrete Lined Channel Section	2,314	
East P Street to Upstream End	538 Q	Manmade Concrete Lined Channel Section	2,816	
B112-05-00				
B112-00 to Cunningham Dr.	578 G	Manmade earthen roadside ditch in Fairmont Parkway right-of-way.	2,071	
Cunningham Dr. to Center Street	578 CB	Manmade Earthen Channel Section	4,414	

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Reach/Location	Key Map	Description of Channel	Length (Ft.)	Detention Acreage
B112-06-00				
B112-00 to Avenue P	538 U	Manmade Earthen Channel Section	984	
Avenue P to San Augustine	538 Q	Manmade Earthen Channel Section	1,869	
San Augustine to X Street	538 Q	Manmade Earthen Channel Section	2,272	
B113-00-00				
B100-00 to Jana Lane	578 LKE	Manmade Earthen Channel Section	8,671	
Jana to B113-01	578 E, 577 M	Manmade Earthen Channel Section	3,179	
B113-01 to Beltway 8	577 ML	Manmade Earthen Channel Section	4,474	
Beltway 8 to B113-03	577L	Manmade Earthen Channel Section	1,855	
B113-01-00				
B113-00 to upstream end	577 M	No channel--Replaced by storm sewer	1,931	
B113-03-00				
B113-03 to upstream end	577 KF	No channel--Replaced by storm sewer	4,871	
B114-00-00				
B100-00 to Spencer Highway	578 A, 538 W	Manmade Earthen Channel Section	1,043	
Spencer Highway to Red Bluff Road	538 W	Manmade Earthen Channel Section	2,025	
Red Bluff Road to Glenwood Avenue	538 X	Manmade Earthen Channel Section	914	
Glenwood Avenue to B114-02	538 XT	Manmade Earthen Channel Section	3,587	
B114-01-00				
B114-00 to Red Bluff Road	538 TS	Manmade Earthen Channel Section	3,329	
B114-02-00				
B114-00 to upstream end	538 T	Manmade Earthen Channel Section	682	
B115-00-00				
B100-00 to Jana Lane	578 A	Natural Earthen Channel Section	2,735	
Jana Lane to B115-01	578 A, 577 D		2,861	

Reach/Location	Key Map	Description of Channel	Length (Ft.)	Detention Acreage
B115-01 to B115-03	577 D		627	
B115-03 to Beltway 8	577 D		1,967	
Beltway 8 to B115-02	577 DC	Manmade Earthen Channel Section	1,913	
B115-02 to Upstream End	577 G	Concrete Lined Manmade Channel Section	758	
B115-01-00				
B115-00 to Beltway 8	577 D	Manmade Earthen Channel Section	1,929	
Beltway 8 to Pansy Street	577 DC	Concrete lined channel adjacent to Old Vista in roadway right-of-way	2,169	
Pansy to Crepe Myrtle Street	577 C	Manmade Earthen Channel Section	3,105	
Crepe Myrtle Street to Spencer Highway	577 C	No channel--Replaced by storm sewer	1,794	
B115-02-00				
B115-00 to Pansy Street	577 G	Manmade Earthen Channel Section	763	
Pansy Street to Colombia Drive	577 G	Manmade Earthen Channel Section	2,729	
Colombia Drive to Upstream End	577 C	Manmade Earthen Channel Section	2,713	
B115-03-00				
B115-00 to Pineneedle Street	577 D	Manmade Earthen Channel Section	869	
B116-00-00				
B100-00 to Heathfield Street	578 FE	Manmade Earthen Channel Section	3,290	
B117-00-00	577 D, 537 Z	No longer a ditch, within B500-01 basin.	1,473	
B204-04-00				
B104-00 to B104-04	618 A, 578 W	Manmade Earthen Channel Section	1,442	
B500-01-00 (Spencer Highway Basin)				
On B100-00 d/s of Spencer Highway	537 Z, 577 D			43 acre site
B500-02-00 (Fairmont Parkway Basin)				
On B100-00 u/s Fairmont Parkway	578 BF			45 acre site
B500-04-00 (Red Bluff Road Basin)				
On B100-00 at confluence w/ B114-00	538 W, 578 A			85 acre site
B504-01-00				
On B104-04 d/s Ellington Field	577 V, 578 S			36 acres
B504-02-00				
On B104-04 u/s Clear Lake City Blvd.	578 W			
B504-03-00				
On Clear Lake City Blvd at El Dorado	578 X			16 acres
B504-04-00				
On B104-00 near Space Center Blvd.	617 D			18 acres
B512-01-00 (Underwood Road Basin)				
On B112-02 u/s Spencer Highway	538 Z, 539 W			80 acre site
B513-01-00				
On B113-00 at Baywood Subd.	578 JK	Developer basin in Baywood Subdivision.		
B513-02-00 (Baywood Basin)				
On B100 at confluence w/ B113-00	578 LK			135 acre site
B513-03-00 (Anthony Road Basin)				
On B113-00 d/s Beltway 8	577 LM			125 acre site
B516-01-00				

Appendix I. Existing Water Quality Outreach Efforts

Water Quality Promotional Materials

- Armand Bayou Watershed roadside signs

  Houston-Galveston Area Council will place roadside watershed signs in the area. The basic sign design approved, funds were made available and sites for sign placement were chosen.
- Armand Bayou Watershed brochure

  Tri-fold brochure highlighting the watershed and some of its more prominent features and threats. Online at: http://www.h-gac.com/ (Type "Armand Bayou" into search box at upper right, should be the first link that comes up, but check to make sure it has 8818 in name. Opens very slowly.)
- Loop trail brochure

  Self-guided driving trail in and around Galveston Bay. The Galveston Bay Foundation received a grant from the Galveston Bay Estuary Program to develop a brochure of a driving self-tour of the many wonders of the Galveston Bay Estuary. (http://galvbay.org/)
- "Clean Water Clear Choice"

  Extensive outreach campaign, complete with logo, canvas bags, folders with pamphlets, magnets, etc. (http://www.cleanwaterclearchoice.org/)
- "Pasadena, Coastal City"

  Series of 12 x 30 minute videos highlighting water quality and Armand Bayou, airing monthly on local access cable TV; available to other cities for use as well. (http://www.ci.pasadena.tx.us/news.htm#TV62)
- No Dumping video

  Ten-minute video, volunteers take to 3rd to 5th grade classes.
- Construction fact sheet (pending)

  One-page fact sheet, for building permit applicants.
- Construction Site Best Management Practices manual (pending)

  Developed by a local Construction BMP Alliance. Being printed by Texas Cooperative Extension/Texas Sea Grant on a grant form the Galveston Bay Estuary Program (www.urban-nature.org)
- Landscape regulation / education

  Code enforcement officers stop landscapers and yard maintenance personnel when they see them blowing grass clippings into the curb drains.
- WaterSmart Landscaping brochures

  Brochures that explain the benefits – both environmental and personal – of proper plant selection and maintenance.

  http://www.urban-nature.org/publications/pef/WS-organicLawnCare.pdf

  http://www.urban-nature.org/publications/pef/WS-WatersmartBrochure.pdf
- Children's art calendar

  Fifth graders artistically incorporate important Bay facts and dates in a popular calendar distributed to area residents, decision-makers and supporters.
- TCEQ water quality programs, efforts, and activities

  http://www.tceq.state.tx.us/AC/nav/eq/eq_water.html

  Refer to TCEQ publications list: http://www.tnrcc.state.tx.us/admin/topdoc/ or http://www.tnrcc.state.tx.us/cgi-bin/exec/publications.pl
- Websites, newsletters, etc.

  Most organizations have websites with a wealth of information available. Organizations with members (such as nonprofits and homeowners' associations), municipalities, and others, such as water districts, have newsletters that are mailed out – and often posted online.
- Teacher Tool Kit - http://www.tpwd.state.tx.us/edu/teacher.phtml
- Wildlife Posters and Fact Sheets - http://www.tpwd.state.tx.us/edu/posters.phtml

Workshops and Classroom Activities about Water Quality and Watersheds

- Master Naturalists

  Intensive several-month week training educates people about the ecology of the area and then creates a network of volunteers for various ecological restoration projects.

  http://www.tpwd.state.tx.us/nature/volunteer/txmasnat/
- Master Gardeners

  Intensive several-month training educates people about the proper planting and care of landscapes and yards. http://aggie-horticulture.tamu.edu/mastergd/mg.html
- Collaborative education workshop (pending)

The groups are working to coordinate awareness and distribution of water quality and stormwater educational materials.

- Water-related eco-classes

  Classes for students from K-12 (depending on course): Water Water Everywhere, Night / dawn/ sunset boat rides, Night hikes, Pond Pal classes, Bayou Studies, EcoCamp, self-guided trail with activity packets, Nature Discovery Classes, etc.—may include dipnet, seine, microscope, talks from staff/volunteers, etc.

- Bay Ambassadors

  Galveston Bay Foundation trains volunteers speak to students at their schools to talk about water quality and relationship to Galveston Bay. (ww.gbf.org)
- "Estuaries Live"

  25 September 2003, out of ABNC—Students and educators from around the country log in for live interaction with experts on estuaries, watersheds, and water quality. (http://www.estuarylive.org/)
- WaterSmart Landscaping Workshop

  One-day workshop and plant sale, offering a multitude of talks about various topics related to smart gardening. (http://www.watersmart.cc/)
- Galveston Bay Yards and Neighbors Program

  Community based education program educates homeowners on "Bay Friendly" home and lawn care practices which help reduce excess use of potential non-point source pollutants that may end up in Galveston Bay. (http://aggie-horticulture.tamu.edu/galveston/galveston_bay_yards_&_neighbors.htm)
- San Jacinto Marsh Restoration Project

  The San Jacinto Battleground State Historical Park preserve is the oldest and most visited state park in Texas and the site of the Marsh Restoration Project. It serves as a centerpiece of natural history training for teachers of K - 6 children. (http://www.eih.uh.edu/education/sjmp.htm)
- Science of Galveston Bay

  Interactive lesson plans show teachers and representatives of local parks and recreation departments how to integrate information about the Bay into their curricula and programs.
- Brown bag lunch lectures

  The Environmental Institute of Houston offers bring-your-own lunch lectures, by a variety of guest speakers, about local environmental issues.
- Citizens' Advisory Panels (CAPs) / Citizens' Advisory Councils (CACs)

  Created to encourage dialogue between chemical plant owners/operators and local neighborhood representatives, CAPs and CACs generally discuss local issues of concern, including environmental threats.
- Hunter, Boater and Angler Education

  Hunter education teaches hunting safety, skills and responsibility. The Texas Boater Education Program stresses boating safety and responsibility. Angling instructors provide several levels of angler training.
- Outdoor Kids

  Outdoor Kids is a self-paced program encouraging young people to experience firsthand the natural, cultural and recreational resources of Texas under the guidance of an adult leader--for instance, a Scout troop leader, a teacher, or a parent.
- Project Wild

  Project WILD/Aquatic WILD is 'Wildlife in Learning Design" - a Kindergarten - 12th grade environmental and conservation education program emphasizing awareness, appreciation and understanding of wildlife and natural resources.
- Community Outdoor Outreach Program

  Builds relationships with non-traditional constituencies who have been underrepresented in Texas Parks & Wildlife activities and programs
- Master Naturalists

  Intensive several-month training educates people about the ecology of the area and then creates a network of volunteers for various ecological restoration projects. (http://www.tpwd.state.tx.us/nature/volunteer/txmasnat/)
- Texas Nature Trackers

  Texas Nature Trackers, associated with the Texas Master Naturalist Program, is a citizen science monitoring effort designed to involve volunteers of all ages and interest levels in gathering scientific data on species of concern in Texas through experiential learning.
- Teacher Tool Kit (http://www.tpwd.state.tx.us/edu/teacher.phtml)
- Wildlife Posters and Fact Sheets (http://www.tpwd.state.tx.us/edu/posters.phtml)
- Becoming an Outdoors Woman

  Provides an atmosphere where women feel comfortable learning new skills associated with hunting, fishing, and other outdoor activities, in a supportive and non-threatening environment.
- Wildscapes

  Texas Wildscapes is a habitat restoration plan for rural and urban areas. Texas Wildscapes are small habitats that provide the essential ingredients for a variety of wildlife-food, water, shelter, and space. This is done by planting and maintaining native vegetation, installing birdbaths and ponds and creating structure. http://www.tpwd.state.tx.us/nature/wildscapes/
- Private Lands and Habitat Enhancement

  The goal of the Private Lands and Habitat Program is to provide expertise to land managers in the preservation and development of wildlife habitat and the proper management of the various wildlife populations which utilize that habitat. (http://www.tpwd.state.tx.us/conserve/private_lands/)
- Landowner Incentive Program
- Incentive programs to assist private landowners in protecting and managing rare species can have a direct and positive impact on their conservation. It is the goal of this program to provide financial incentives that encourage landowners to help conserve rare species. (http://www.tpwd.state.tx.us/conserve/lip/)