Buffalo & White Oak Bayous
Bacteria TMDL Stakeholder Group
March 7, 2002

Stakeholders Present: Neil Bishop, Linda Broach, Claire Caudill, Ralph Calvino, Catherine Elliott, Theo Glanton, Terry Hershey, Colleen O'Brien, Mike O'Brien, Linda Shead, Cathy Troisi (representing Cynthia Chappell), Mary Ellen Whitworth

Stakeholders Absent: Bennie Billington, Brenda Bradley, Cynthia Chappell, Rod Hainey, Scott Jones, Helen Lane, Carole Lenz, Mike McClellan, Trent Martin, Mike Montgomery, Donna Phillips, Evelyn Born Shanley, Kerry Whelan

Support Team Present: Paul Jensen, Earline Lambeth, Carl Masterson, John Matthews, Tina Petersen, Hanadi Rifai, Ron Stein, Yu-Chun Su, Pris Weeks

Others Present: Michael Bloom (PBS&J), Kirk Dean (Parsons)

Materials Distributed:
- 3/8/01 meeting summary
- 3/7/02 meeting agenda
- Ground rule revisions
- Paul Jensen's PowerPoint presentation of the Clean Rivers Research Update
- Hanadi Rifai's PowerPoint presentation of the second research report

1. The meeting for the Buffalo and White Oak Bayous Bacteria TMDL Stakeholder Group was held on Thursday, March 7, 2002, from 6:30 to 9:00 PM at the H-GAC offices, 3555 Timmons Lane, Houston, Texas 77227, 2nd Floor, Conference Room A. **Pris Weeks** of the Environmental Institute of Houston (EIH) welcomed participants and self-introductions were made. The meeting agenda was approved.

2. **Ron Stein** (TNRCC) was introduced as the new project manager for the group, and **Earline Lambeth** was introduced as the new public outreach coordinator. Pris Weeks then presented the revised ground rules for the group. These were approved without comment. It was decided that the full version of the ground rules would be emailed to all members.

3. The notes from the March 8, 2001, meeting were then presented. **Cathy Elliot** stated that **Trent Martin** was not with Harris County Flood Control, as shown in item 2 of the notes, but with another county department. No other comments were made regarding the previous meeting's notes.

4. **Pris Weeks** then noted that **Linda Shead** was retiring from the Galveston Bay Foundation the following week but wished to retain a position as a stakeholder with this group. **Paul Jensen** and **Terry Hershey** nominated her for membership; the rest of the group approved the change.

5. **Pris Weeks** then asked **Paul Jensen** to present information on a research project from Clean Rivers regarding Buffalo and White Oak bayous. He began by saying that the details of the report will be posted on the H-GAC website. This research project began as an effort to distinguish between human and nonhuman sources of bacterial pathogens. Two researchers (**Shelley Payne** and **Ana-Maria Valle**) at the University

of Texas at Austin used polymerase chain reaction (PCR) techniques to determine the sources of *E. coli* (e.g., humans, wildlife, or pets) and to analyze the accuracy of using *E. coli* levels as indicators of waterborne pathogens. For the latter goal, *E. coli* levels would be compared with two bacteria closely associated with humans. These two species (referred to as Bd and Bt) are both obligate anaerobes of the genus *Bacteriodes*. *E. coli* is a facultatively anaerobic species.

For reference, *E. coli,* Bd, and Bt concentrations were compared in raw and untreated sewage, treated and chlorinated wastewater, and treated and dechlorinated wastewater. For *E. coli,* the chlorinated concentrations were about 30 percent of raw sewage levels, while dechlorinated samples showed 0 percent of raw sewage levels.

Because Bd and Bt are obligate anaerobes, the aeration process used to dechlorinate wastewater is lethal. Bd levels dropped to 90 percent of raw sewage concentrations in chlorinated wastewater and to 0 percent in the dechlorinated samples. Bt concentrations fell to 30 percent in chlorinated samples before hitting 0 percent in dechlorinated samples.

Linda Broach asked how many bayou samples were taken. **Paul Jensen** replied that there were twelve samples.

Researchers tested every bayou sample for *E. coli.* If *E. coli* was detected, then the researchers also tested for Bd and Bt to look for correlation between the three. Bacterial levels were scaled against raw sewage levels. Buffalo Bayou samples were roughly 40 percent for *E. coli*, 10 percent for Bd, and 5 percent for Bt. White Oak Bayou concentrations were about 70 percent for *E. coli*, 20 percent for Bd, and 20 percent for Bt. To Paul Jensen, these results suggested that *E. coli* could be providing many false positives -- suggesting the presence of other pathogenic bacteria that may not actually be present.

The researchers also suggested that *Bacteriodes* species might provide a good indicator species alternative to *E. coli* when dealing with raw sewage. Bd and Bt seem less appropriate for treated wastewater. Of the two, Bd is a more revealing marker than Bt; it was found in a total of 16 percent of all of bayou samples that also contained E. coli. The researchers also noted that White Oak Bayou had higher Bd concentrations than Buffalo Bayou, and that a small White Oak Bayou tributary had still higher levels. Paul Jensen then asked for comments and questions.

Linda Broach asked how long *Bacteriodes* survived in the samples. **Paul Jensen** replied that the testers were not looking at survival rates, only the presence of Bt and Bd. **Cathy Troisi** asked if either species was known to be infectious. **Paul Jensen** stated that they were simply markers for human sewage. **Linda Broach** wanted to know what the Clean Rivers research suggested to him if 80 percent of the *E. coli* was from nonhuman sources. **Paul Jensen** thought that birds and other wildlife might be contributing. **Linda Broach** wondered why other bodies of water didn't exhibit comparable levels. **Paul Jensen** and **Hanadi Rifai** said that the Buffalo Bayou and White Oak Bayou concentrations were typical for urban freshwater systems. **Catherine Elliott** asked if the researchers had looked at bacterial contributions from surrounding soils. **Paul Jensen** said no; this Clean Rivers project was only a small step along the path of finding more accurate pathogenic markers. **Carl Masterson** then asked if this research project was inconclusive; could we could

make its results more helpful? **Paul Jensen** replied that the research may or may not be helpful; natural sources of *E. coli* may be important players. **Catherine Elliott** then asked what the next step should be from this research. This project represents a single, closed project from Clean Rivers, **Paul Jensen** replied, with no specific next step.

Pris Weeks then asked what **Paul Jensen** would suggest as a next step. He said that we must focus on *E. coli:* What are its sources? Why do we find it or not find it? Are there better markers than *E. coli*? **Neil Bishop** then asked what turbidity interference meant. Jensen said that the researchers were concerned that high levels of turbidity might affect the PCR analysis.

6. At this point, **Hanadi Rifai** then stood to present the results of her second official report, entitled "Total Maximum Daily Load for Fecal Pathogens in Buffalo Bayou and White Oak Bayou." The report's fieldwork had begun in July 2001. Her research had three major goals.

   The first goal was to assess responses of indicator bacteria in Buffalo and White Oak bayous following moderate rainfall events over a three-day period. There were four monitoring stations on Buffalo Bayou and three on White Oak Bayou, including one tributary of White Oak Bayou. The two monitoring periods occurred between August 7 and 9, 2001, and between August 28 and 30, 2001.

   Several trends were apparent from both rainfall events. Runoff levels were correlated with *E. coli* levels, suggesting that runoff is a major bacterial contributor. Also, while flow rates correlate with *E. coli* levels, bacterial levels can change rapidly following a runoff event. By taking a series of samples over each three-day event, the researchers concluded that the timing of sampling in relation to a rain or runoff event greatly affects the record of *E. coli* levels.

   The second research goal was to analyze bacterial population dynamics along three dimensions: the influence of light and darkness on *E. coli* concentrations, the regrowth of bacteria in suspension, and the connection between sediment disturbance and suspended bacterial concentration.

   To study the role of light conditions and turbidity on *E. coli* levels, a floating isolation tank was designed to hold samples in chambers at each bayou monitoring station. Three study sites were located on Buffalo Bayou and two on White Oak Bayou. Each chamber in the isolation tank could be open to the air or closed. Each chamber could also be either "light" (admitting daylight) or "dark" (covered, simulating turbid conditions). The floating isolation tank allowed the samples to remain in actual bayou conditions. *E. coli* die-off rates were measured for three conditions: light and open, light and closed, and dark and closed. The control chamber contained de-ionized water instead of bayou-derived samples.

   E. coli in all chambers followed first-order decay rates, with all experimental populations falling about 60 percent within twenty-four hours. Researchers speculated that the die-off rate may actually reflect bacterial settling. The dark, covered chambers did not have slower die-off rates as had been predicted. The team concluded, then, that bacterial levels seemed independent of light conditions and turbidity.

The second dimension was to determine if bacterial levels reflected "regrowth" -- the maintenance of *E. coli* populations in suspension over time without additional inputs. The chambers did not show significant levels of *E. coli* regrowth near wastewater treatment plants (WWTPs), suggesting that regrowth contributes little to *E. coli* levels. Although all sites showed signs of some *E. coli* regrowth, total coliform counts did not follow the same pattern. The most anomalous site was the West District WWTP on Buffalo Bayou, which showed extremely high initial *E. coli* readings. However, records from the plant document a mechanical problem that resulted in the emission of unchlorinated wastewater into Buffalo Bayou preceding sample collection.

For the third dimension, the team investigated the role of *E. coli* living in the sediment that might be elevating or "resupplying" suspended *E. coli* concentrations when that sediment is disturbed by runoff events. Circumstantially, *E. coli* levels tend to rise going downstream. Also, direct measures of *E. coli* concentrations in sediments tended to be an order of magnitude higher than suspended concentrations.

The sediment disturbance hypothesis was tested by stirring chamber samples five days after initial runoff events for 10 seconds. *E. coli* levels increased dramatically after stirring. **Catherine Elliot** then asked if sediments for the chambers were sampled near the shore or from the center of the bayou channels. **Yu-Chun Su** stated that samples were taken by wading into waste-deep water.

Hanadi Rifai then stated that the third broad research goal focused on assessing the relative effects of point-source WWTPs versus unknown, illicit nonpoint discharges.

There are 128 WWTPs along both bayous in the delimited zone, and 76 of these were sampled. Samples were taken twice in one day. Less than 10 percent of these WWTPs were outside regulatory limits for *E. coli* or fecal coliform levels.

To estimate illicit discharge amounts, storm sewers emptying into the bayous were monitored during dry weather. Almost 45 percent of the 38 pipes sampled violated *E. coli* limits, and 27 percent had excessive fecal coliform levels. She concluded that storm sewers (and illicit discharges into the storm sewer system) may be a bigger problem than WWTPs.

After completing her presentation of the research findings, **Hanadi Rifai** then turned to the process of preparing a model for the bacterial system. The subwatersheds have been delineated very near to flood control watershed boundaries. Upstream reservoirs, however, are not included in the watershed, which could be problematic as their discharges elevate the background *E. coli* levels for these bayou segments. Much data for the model is coming from H-GAC and from 2000 satellite images. Preliminary model output now combines several point sources. An immediate focus of work is model calibration. She quickly summarized the report's findings again and then asked for comments.

Catherine Elliott said that we should track down whether or not sediments are a major source of *E. coli,* and then we should track down the source of infection of the sediments. Hanadi Rifai replied that her team could not yet quantify the sediment percentage contribution. **Linda Broach** wanted to know what made Houston-area bayous special and how Buffalo Bayou and White Oak Bayou compared to other streams without bacterial problems. She also wanted to know what kinds of inputs

could create this sediment problem? Resuspension is not unusual in natural systems. **Paul Jensen** stated that our system is hard to model. Natural streams have a different hydrology from those modified for flood control to keep velocity and turbulence at high levels.

Catherine Elliott asked what other urban coastal areas have similar conditions. **Paul Jensen** said that Beaumont, Port Arthur, and Pearland are analogous but show less severe conditions. **Hanadi Rifai** said that exceedences are lower in the Rio Grande Valley in spite of raw sewage discharges from *colonias*. The problem is more severe in urban areas.

Claire Caudill wondered if missing WWTPs could be contributing. **Hanadi Rifai** said that only about 10 to 20 percent of WWTPs are problematic. Moreover, WWTPs are under TNRCC authority, but the missing WWTPs did not grant sampling authority to her. **Linda Shead** added that TNRCC provided assistance to help keep suspended solids within each plant's treatment system. Smaller plants may be harder to manage. **Carl Masterson** agreed; it may also be harder to observe outputs from smaller plants. **Hanadi Rifai** suggested that TNRCC address the WWTP problems.

Terry Hershey asked what effect the unsampled 45 WWTPs have on the system. Who samples them? **Hanadi Rifai** said she did not have the authority to sample their emissions without local permission. **Linda Broach** added that TNRCC has the authority to sample all WWTPs, but probably not frequently enough. TNRCC literally has the keys to these WWTPs.

Neil Bishop added that it would be interesting to compare differences between White Oak Bayou and Buffalo Bayou since most WWTPs are in White Oak Bayou. Why aren't the plants more randomly distributed? Tina Petersen stated that the larger, consolidated plants empty into Buffalo Bayou, but the smaller and newer plants are concentrated on White Oak Bayou. **Carl Masterson** stated that development and agriculture are important sources in area reservoirs. **Linda Broach** agreed, saying that the bayou bacterial levels start at high levels at the reservoir release point.

Michael Bloom wondered if the PBS&J level too high. **Hanadi Rifai** and **Carl Masterson** both agreed. Michael then asked if this situation is like the air quality model? **Carl Masterson** said the water quality situation is not as intractable. **Paul Jensen** said the bigger issue may concern higher-flow phenomena. **Hanadi Rifai** added that runoff in the reservoir could be a big issue with high flows, making the operating system unique. **Paul Jensen** suggested we need to focus on high flow conditions at high velocity. Now the question is, how do we support contact recreation use? Perhaps we should look at lower flow levels as bacterial levels at low flow rates may be more achievable.

Mary Ellen Whitworth wondered how the bacterial die-off rate of the sediments compared with the rates of the water-column bacteria. **Paul Jensen** replied that the sediments are a reservoir -- a habitat -- of bacteria, which live longer there. **Yu-Chun Su** mentioned that bacterial levels are high after a sediment disturbance, even when there are few inputs upstream.

7. **Pris Weeks** then introduced the group's new TNRCC coordinator as the person tasked to complete our project. **Ron Stein** stood and said that he felt there were

three factors affecting the solution. First, bayous are not natural systems and do not have a natural ecology, with natural predator-prey communities. Moreover, EPA-defined criteria for a single bacterial species may not be reasonable. Indeed, the EPA is considering new bacterial criteria. Since the contributions of wildlife to urban water quality has not been well defined, we may need to adjust the acceptable limits to fit our situation.

Second, the water systems in question are complex. There are multiple sources, especially nonpoint sources, reflecting the location of White Oak Bayou and Buffalo Bayou in a large urban area. Sediment mixing will be always be significant in an area with 50 inches of rain a year. These complexities mean that the solution to the water quality problem must be cooperative. Everyone living in this watershed must contribute to reducing the bacterial load. It is notable that small WWTPs releasing less than one million gallons per day have different reporting mechanisms than larger WWTPs. This group must consider what behavior of the watershed's inhabitants must be changed to achieve compliance.

Third, the upstream boundaries of this TMDL group need to be reconsidered. The current boundaries stop just where many important sources are located. Other segments -- particularly those upstream -- may need to be included in the solution. It may be most useful to think of the greater watershed to improve our segments.

Technically, socioeconomically, and cooperatively, we must work towards a solution. At this point, we cannot predict what that solution will look like. He is awaiting the third quarterly report. Along with some modeling studies, he plans to go the EPA and talk about our particular challenges and complexities and have the EPA think of the larger watershed. With their help, we can search for a solution without getting bogged down or too exact over rigorous limitations. This may be a standard-setting case as it is the first major urban bacterial load group. He wants input from all parties.

Pris Weeks then asked what steps **Ron Stein** could see next in the TMDL process. He replied that he's still learning and is not sure what steps come next.

Colleen O'Brien said she perceived the TMDL process as a way to make better the bayous but had several basic questions. What impact do fertilizers have on the bacterial load, for instance? Are fertilizers an indirect nonpoint contributor? What data exists on this subject? Is there any fertilizer data to compare with our segments? **Ron Stein** said that when fertilizers are identified, they are usually subsources.

Terry Hershey stated that we also need to talk about getting the word out to citizens about their role in water quality. She asked how many members present at this meeting had attended the previous weekend's Watersmart program. **Catherine Elliott** said that Watersmart focused more on landscaping, which **Terry Hershey** said also related to yard runoff.

Several people were concerned about data on the correlation between bacterial growth, fertilizers, and manures. **Colleen O'Brien** wanted more information on this topic, especially in regard to systems similar to our segments. **Paul Jensen** agreed, and he also felt that we should confirm or eliminate the effect of bird populations on bacterial levels, particularly in dry weather. **Linda Broach** said that we needed to

consider what might make Houston special as a case -- does Houston have more birds or fertilizer use?

Colleen O'Brien added that changes in the storm water system could lower settling rates. **Claire Caudill** then said that even with such changes, these segments still wouldn't be meeting dry weather standards.

Linda Shead thought there were two separate concerns: wet and dry. We might have to make one of these a priority in finding a solution. She also expressed nervousness about lowering standards as a solution rather than trying to restore aquatic systems within existing standards. **Carl Masterson** added that those standards were set for health reasons. He could often see children and homeless people swimming in these bayous and lowering standards might have consequences. **Linda Broach** suggested beginning with what we can fix first. **Linda Shead** said we must also consider how much of the current situation is a legacy from having little or no treatment in the past. How has this history affected the predator-prey community? We should not forget about the past of these legacy pollutants and their ongoing contributions. **Linda Broach** agreed, saying that the addition of inputs now raises the equilibrium of the system, and the reduction of those inputs reduces the equilibrium.

Hanadi Rifai stated that the twenty-year data showed tremendous improvement, but the current model does not assume inputs upstream of our segments, as if these bayous were natural streams. But the background loads are already higher than standards at the beginning of the segments due to upstream sources. **Linda Shead** replied that the regulatory standards are in place for a reason, and we must use these standards rather than changing them.

Pris Weeks then said that there are obviously several unresolved concerns that need to be summarized. She asked how the model could be used to address these issues.

Paul Jensen stated that with three years of data over a full range of conditions, the research team now wants to see how to model higher flows. More data may be necessary. Even short-term settling allowed bacterial levels to drop dramatically. Therefore, changing the stream geomorphologies may be an important consideration. **Linda Shead** agreed; changing inputs may be less important than other kinds of solutions. We need to look at research on other systems.

8. **Pris Weeks** then apologized for interrupting the discussion and for allowing the meeting to run late. **Hanadi Rifai** said that at the next meeting she would have another quarter's results from her research. **Neil Bishop** turned to **Ron Stein** and asked him if TNRCC was considering adopting a technology-based solution. **Ron Stein** replied that the final solution will be multifaceted, with widespread changes in behavior. But he couldn't be more specific. **Catherine Elliott** then asked if we needed to determine first if the problem really was fixable before proceeding.

   Pris Weeks apologized again, saying that the discussion would have to wait. She predicted that the group would meet within three to four months. Would an afternoon meeting be better? Were any members not attending because of the early evening hours? **Linda Shead** thought a 4 PM to 6 PM meeting might be a better arrangement. **Pris Weeks** promised to have the support team consider this option.