Watershed Protection Plan

Westfield Estates

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

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Houston-Galveston Area Council | P.O. Box 22777 | Houston, TX 77227-2777 | www.h-gac.com

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Westfield Estates Stakeholders Advisory Group

Scott Bean, East Aldine Management District

Paul Jensen, PE, PhD, PBS&J

Robin Brinkmeyer, PhD, Texas A&M University at Galveston

Virgil Fernandez and Anju Chalise, Texas Commission on Environmental Quality

Melissa Hamous and Susan Santos, Harris County Public Infrastructure Department

Steven Johnston, Galveston Bay Estuary Program

Olga Rodriguez and Marco Bracamontes, Harris County Precinct 2 Commissioner's Office

Bill Kneer and Jim Ainsworth, Sunbelt Freshwater Supply District-Oakwilde

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Stakeholders wish to thank Commissioner Sylvia Garcia for the vision and support that have made this Watershed Protection Plan possible.

STATEMENT OF PURPOSE

The Westfield Estates Watershed Protection Plan (Westfield Estates WPP) addresses bacteria water quality issues in a small, urbanized watershed that drains into Halls Bayou (Segment 1006D) in northeast Harris County, Texas. Water in the ditches within this watershed exhibits levels of *Escherichia coli (E. coli)* (an indicator for pathogenic bacteria in water) in excess of the State criteria for contact recreation (swimming and fishing), posing a health risk to members of the community. Halls Bayou is also listed by the Texas Commission on Environmental Quality (TCEQ) as being impaired for bacteria.

The Westfield Estate WPP's overall goal is to improve the water quality in the Westfield Estates Watershed (Watershed) so as to meet the Surface Water Quality Standards for contact recreation within the Westfield Estates Community (Community). To meet this goal, the WPP's stakeholders have selected on-the-ground management measures and practices that will reduce pollutant loads in the watershed.

The specific purposes of the Westfield Estate WPP are to develop stakeholder awareness of water quality issues in the Watershed, develop a comprehensive plan to address bacterial contamination from a variety of sources, and obtain Community commitment to ongoing voluntary management practices. Towards this end, the WPP contains a design and implementation plan with structural and non-structural corrective measures to improve water quality, as well as a focus on integrated Community involvement. An ultimate solution to the human component of bacterial pollution in the Watershed (presumably a sanitary sewer system) will not likely occur for several more years. Therefore, this WPP provides a comprehensive set of interim strategies to protect water quality and human health while the long term solution for the human component of bacterial contamination is being addressed.

H-GAC, along with Watershed stakeholders, has prepared this Plan in accordance with guidance for Watershed Protection Plans issued by the U.S. EPA. In compliance with Section 2.4.2 of EPA's Watershed Handbook, this Plan is consistent with current Total Maximum Daily Load (TMDL) plans under development for the Houston Metropolitan area and will be revised as necessary to remain consistent with future TMDL reports.

FOREWORD

The Westfield Estates WPP was developed with funds from 604 and 319 grants from the Texas Commission on Environmental Quality (TCEQ), funding from the Galveston Bay Estuary Program, and support from local stakeholders. Under terms of the contract for the Westfield Estates WPP, the first four sections of the Plan were completed in FY08 and the remainder in FY09-FY10.

Justin M. Bower
Senior Environmental Planner
Houston-Galveston Area Council
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TABLE OF CONTENTS

FIGURES

TABLES

ACRONYMS

ac-ft/hr	Acre-feet per Hour
AWQC	Ambient Water Quality Criteria
BMP	BMPs
CAFO	Concentrated Animal Feeding Operation
CDBG	Community Development Block Grant Program
CDC	Centers for Disease Control and Protection
CFU	Colony Forming Units
cfs	Cubic Feet per Second
City	City of Houston
CMP	Corrugated Metal Pipe
Criteria	USEPA Water Standard Criteria for Contact Recreation – 1986
CRP	Clean Rivers Program
CWA	Clean Water Act
dL	Deciliters (100 mL)
DNA	Deoxyribonucleic acid
EAMD	East Aldine Management District
E. coli	Escherichia coli
EDAP	Economically Distressed Areas Program
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FSSI	Failing Septic System Initiative (Phase I)
FWSD	Sunbelt Freshwater Supply District - Oakwilde
FY	Fiscal Year
GBEP	Galveston Bay Estuary Program
GBP	Galveston Bay Plan
GI	Gastrointestinal
GIS	Geographic Information System
GLO	Government Land Office
HC	Harris County, Texas
HCAD	Harris County Appraisal District
HCOEM	Harris County Office of Emergency Management
HCPCT2	Harris County Precinct 2
H-GAC	Houston-Galveston Area Council
HSPF	Hydrologic-Simulation Program-Fortran Model
LDC	Load Duration Curve Model
mL	Milliliter
MPN	Most Probable Number (of bacteria)
MPS	Meters per second
MRA	Microbial Risk Assessment
MS4	Municipal Separate Storm Sewer Systems
MSS	Malfunctioning Septic System
MST	Microbial Source Tracking
NCR	Non-Contact Recreation

NEP	National Estuary Program
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source pollution
NRAC	Natural Resources Advisory Committee, H-GAC
OSSF	On-site Sewage Facility Westfield Estates Watershed
PCR	Polymerase Chain Reaction
Phase I	Westfield Estates WPP Phase I
PID	Public Infrastructure Department
Plan	Westfield Estates Watershed Protection Plan
POTW	Publicly Owned (wastewater) Treatment Works
PSG	Permanent Stakeholder Group
qPCR	Quantitative Polymerase Chain Reaction
RNA	Ribonucleic Acid
SAG	Stakeholder Advisory Group
SD	Standard Deviation
PID	Public Infrastructure Department
QAPP	Quality Assurance Project Plan
SRF	State Revolving Fund (Loans)
SSM	Single Sample Maximum
SSO	Sanitary Sewer Overflow
STAG	State and Tribal Assistance Grant Programs
SWMM	Storm Water Management Model
TCEQ	Texas Commission on Environmental Quality
TMDL	Total Maximum Daily Load
TPDES	Texas Pollutant Discharge Elimination System
TWDB	Texas Water Development Board
UAA	Use Attainability Analysis
U.S.	United States
USGS	United States Geological Survey
WALD	Watershed Aggregate Load Determination
Watershed	Westfield Estates Watershed
Westfield Estates WPP	Westfield Estates Watershed Protection Plan
WPMT	Watershed Plan Management Team
WPP	Watershed Protection Plan
WQS	Water Quality Standards
WWTP	Wastewater Treatment Plant

WATERSHED PROTECTION PLAN: WESTFIELD ESTATES WATERSHED

EXECUTIVE SUMMARY

The Westfield Estates Watershed (Watershed) is an urbanized sub-watershed of Halls Bayou, located in unincorporated northeast Harris County, Texas. The Westfield Estates Community (Community) is a neighborhood that encompasses the majority of the Watershed area. Growing concern over bacterial contamination in the Watershed led to the development of this Watershed Protection Plan (WPP) as a joint effort between Community stakeholders and the Houston-Galveston Area Council.

Based on studies conducted in Phase I of this WPP, many locations within the Watershed exhibited bacterial contamination (often well in excess of 100,000 Most Probable Number of bacteria[MPN]/100milliliters [mL]) exceeding the criteria for contract recreation according to the State of Texas' Surface Water Quality Standards[1]

Therefore, the goals of the Westfield Estates Watershed Protection Plan (Westfield Estates WPP) are to reduce bacteria levels from human and nonhuman sources in the Watershed to meet the aforementioned criteria and to provide for the maintenance of the achieved improvements in water quality. The objectives of Phase II of this WPP are to facilitate these goals by further characterizing the Watershed, prescribing and implementing structural and behavioral Best Management Practices (BMPs), instituting long range management practices to maintain improved water quality, and developing awareness and Community involvement in watershed issues.

Pursuant to these goals and objectives, this WPP focuses on nine core elements, as set forth by the EPA in their Nonpoint Source Program and Grants Guidelines for States and Territories[2]. These elements are: 1. An identification of cause and source of water quality issues, 2. A projection of expected load reduction(s), 3. Proposed management measures, 4. An assessment of technical and financial assistance needed, 5. An information, education, and public participation component, 6. An implementation schedule, 7. Evaluative milestones, 8. Load reduction evaluation criteria, and 9. A monitoring component. A summary of the nine elements of this WPP and their respective locations in this document can be found in Table 1.

Using these nine core elements as a framework, the Westfield Estates WPP was developed through a stakeholder involvement process, led by a Stakeholders Advisory Group (SAG). This interdisciplinary team of stakeholders used the expertise of water quality professionals, elected officials and their representatives, and other interested parties to provide resources, technical assistance, and expertise throughout the planning process. This plan has been designed to give the SAG the flexibility to make future amendments as conditions and opportunities warrant, as

[1] As codified in Texas Administrative Code, Title 30, Part 1, Chapter 307, Rule §307.7, section (b)(1)
[2] Environmental Protection Agency, 2003. Nonpoint Source Program and Grants Guidelines for States and Territories. (*Federal Register: October 23, 2003 (Volume 68, Number 205)]*

stakeholder commitment to prevent future degradation of water quality is an integral part of the Plan.

A review of the data collected in the first phase of the Westfield Estates WPP, in conjunction with field reconnaissance observations and stakeholder input, revealed that a significant amount of the bacterial loading in the shared waterways of the Community (primarily drainage ditches) was being contributed by malfunctioning or otherwise inadequate on-site sewer facilities (OSSFs), especially in dry periods. When bacterial source tracking (BST) was applied to the data, 16% was of human origin and 50% was from nonhuman sources (primarily domestic dogs and chickens; 32.5% and 17.5%, respectively). The origin of the remaining 34% has not yet been identified. Previous studies and County records indicated the Community had a widespread issue with malfunctioning OSSFs, which are taken to account for the majority of the human inputs. Based on Hydrologic Simulation Program-Fortan (HSPF) modeling, repair of 175 OSSFs would represent a 57% reduction to their total annual *E. coli* load (for more detail, please refer to Appendix C, Section 1.7). While the Westfield Estates WPP also evaluated and recommends potential reductions from behavioral BMPs related to pet waste, there is not a precise quantification of what those reductions may be. The ultimate goal is an eventual 100% reduction of human contribution when a future sanitary sewer is put in, and a continually growing reduction of pet waste through watershed education and non-structural BMPs.

This WPP outlines several management measures to reduce the bacteria load coming from human and nonhuman sources, including:

- Maintenance, repair, or replacement of malfunctioning OSSFs, or installation of new OSSFs (when feasible),
- Installation, of low-flow devices to reduce influent volumes;
- OSSF maintenance education and contractual maintenance obligation;
- Behavior-oriented BMPs to reduce address pet wastes and trash;
- Institution of a Community watershed education component; and
- Ensuring ongoing stakeholder commitment through the continuation of a Community watershed management group.

Malfunctioning OSSFs

Malfunctioning OSSFs were identified as a priority focus as they represented the loading element for which the greatest degree of regulatory control and potential remediation funding existed. However, given the socioeconomic status of the Community and fairly significant cost involved in remediating the OSSFs, financial and in-kind service commitments had to be obtained from the stakeholders to facilitate this approach. Technical or financial assistance for the construction services/costs related to remediating OSSFs, procuring and installing low flow devices, continued water quality testing, inspection services, drainage improvements and community support were committed by the overlapping political/utility jurisdictions serving the Watershed (East Aldine Management District, Harris County, and Sunbelt FWSD-Oakwilde) as well as other regional stakeholders (H-GAC, Galveston Bay Estuary Program).

Community Education and Participation Component
In order to provide for ongoing maintenance of water quality standards, this WPP also prescribes a community education and participation component. In the tradition of the stakeholder participation model utilized in its creation, the Westfield Estates WPP includes recommendations for the continuance of the SAG, education on the proper maintenance and care of OSSFs, trash reduction events, and a program providing outreach and education about reducing domestic animals wastes.

Implementation
The implementation of the Plan will be an ongoing process but outreach and BMPs are scheduled to begin in fall of FY10. Construction management measures (OSSF remediation, et al.), and additional pre-and post construction water quality monitoring will be the primary short-term foci, followed by, or running concurrently with, a long-term schedule for continued implementation of behavioral BMPs. Several interim milestones have been identified, including the end of pre-implementation monitoring, the start of a watershed-wide low-flow device installation program, completion of subsequent prioritization of malfunctioning/inadequate OSSFs, the start and end of targeted OSSF remediation, and potential subsequent drainage ditch remediation. While sanitary sewer service is the eventual solution for the human sources of bacterial contamination in the Watershed, its prohibitive cost (greater than $16 million) and timeline relegates it to a future implementation phase. Because the ultimate solution is not fiscally or logistically viable in the next few years, these remediation solutions are being pursued to alleviate water quality concerns to the greatest degree practicable in the interim.

The Westfield Estates WPP includes an evaluative model for analysis of the success of the proposed management measures in reducing bacterial loads. Set monitoring locations will be utilized to measure pre- and post-implementation levels. The pre- and post-implementation monitoring component will be guided by an approved QAPP (Quality Assurance Project Plan). The data will be used in conjunction with the model to determine reductions, focused primarily on results related to the OSSF remediation process. As a secondary indicator, the Plan recommend the documentation of reductions in pools of standing water in dry weather caused by pre-existing factors related to bacterial loading (OSSFs, et al.) Additional non-tangible measures of success include the long-term maintenance of a stakeholder group, Community participation levels, and feedback on outreach and educational efforts.

Table 1: Nine Key Elements Summary Table

The following pages incorporate the planning, implementation and evaluation strategies of the WPP into a tabular format to demonstrate their relationships to the Nine Key Elements of the EPA's Watershed Based Plans format (as provided by the TCEQ).

Page references are provided for specific locations, and Section references are provided for those items which are referenced multiple times.

(a) Causes and Sources of Bacterial Impairment (Est. Loads)	(c) Management Measures and Targeted Critical Areas	(b) Estimated Load Reduction Potential From Each Measure (Unit or Total)	(d) Technical and Financial Assistance Needed for Each Measure	(e) Education Component for Each Measure (and Other Education)	(f) Schedule of Implementation for Each Measure	(g) Interim, Measurable Milestones for Each Measure	(h) Indicators to Measure Progress	(i) Monitoring Component	(j) Responsible Entity
Direct Deposition in waterways (Waste from pets and domestic animals, primarily Chickens – representing 17.5% of bacteria loading, and dogs – representing 32.5%, based on HSPF modeling.)	**Stages of outreach, incentive and education programs (pp. 106-114, pp. 118-119, pp. 120-121)**	Additional modeling will be necessary in quantifying reduction of this component (Appendix C).	$12,500 for educational outreach programs and meetings. $4000 for pet waste reduction incentive programs. $5000 for trash reduction activities. (p. 124-126)	Reduce bacteria from non-human bacterial sources through BMPs (pp. 106-114.)	Pet Waste educational mtg. – annually Pet Waste informational materials – ongoing Appearances at local events (re: Pet Waste education) – ongoing Investigate Dog Park/pet waste station - ongoing Domestic Animal waste education mtg. – annually Domestic Animal survey – annually with class (Tables 12, 13, 14)	Written BMPs, publication and distribution of brochures, and holding public meetings. Mitigation of the effects of roaming canines and poultry, and evaluating and potentially remediating other potential sources of bacterial contamination (pg- 121-123)	BMP development, successful distribution of education and outreach materials and activities, observable changes in pet restraint practices and numbers of feral animals in WE, reduction of anthropogenic bacterial loading and decrease in other bacterial contamination (pg 118-123) Before and after surveys (pp. 107-109, p.113, pp.119-120, p.126)	Observable pet waste reduction behaviors, results as part of general post-implementation sampling. (pp. 126-128)	All behavioral measures – H-GAC, TCEQ (oversight), EPA (funding). Select efforts – HCPCT2, TBH, GBEP, FWSD, EAMD. (Sec. 1.5.1)

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Malfunction-ing OSSFs (16% of loading)	Maintenance, repair, and replacement of malfunctioning OSSFs (Interim) (pp. 97-104, Table 11)	Assuming that 70% (175 of 250) of the malfunctioning OSSFs would be fixed, $9.60X10^{14}$ MPN or about 56.8% based on HSPF modeling) (Appendix C)	Part of current Phase II costs of $1,217,500 ($730,500from TCEQ 319 (h) grant Program , $60,000 from EAMD, $110,000 HCPID, $100,000 GBEP, $10,000 HCPCT 2, $2000 FWSD2, $10,000 H-GAC, $190,000 outstanding.) (pp. 124-126)	Education and outreach program on OSSF care and maintenance and behavioral modification of watershed residents (will be available in Spanish also) (pp. 95-97, 98-104, pp.109-, 113, pp.125-126)	Short term (2010-2011) (all schedules, please refer to Tables 11, 12 and 13)	Up to 450-500 homes will be evaluated, estimated half of those needing remediation, first round of inspections for site eligibility , completion of construction plans for eligible sites (pp. 98-104, pp.118, pp.121-123, Table 15)	Completion of qualification criteria and inspection criteria, completed inspections, completed plans for eligible sites, , number of malfunctioning OSSFs remediated.(p.118)	Post-implementation monitoring, survey septic violations, quantify water quality issue reduction, continuing maintenance, Halls Bayou ambient sampling (pp. 126-128)	Structural measures: EPA(funding), TCEQ (oversight), H-GAC (administration), EAMD (construction), HCPCID (survey and site plans), FWSD (criteria, etc) TAMUG, HCPCT2 (Sec. 1.5.1) Behavioral Measures: EPA, TCEQ, HGAC(administration, outreach), EAMD (outreach), FWSD (outreach), HCPCT2 (outreach), TBH (outreach/education)(Sec. 1.5.1)

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Malfunction-ing OSSFs (16% of loading)	Installation of low-flow devices to reduce influent to OSSFs (Interim) (p. 93, p. 101, Table 11)	No load reduction is quantified specifically for this management measure.	Part of current Phase II costs of $1,217,500 ($730,500from TCEQ 319 (h) grant Program , $60,000 from EAMD, $110,000 HCPID, $100,000 GBEP, $10,000 HCPCT 2, $2000 FWSD, $10,000 H-GAC, $190,000 outstanding.) (Pp. 124-126)	Educational meeting on low-flow devices and eligibility. (Pp. 105, p.107, pp.110-111, Table 12)	Short term (2010-2011) (all schedules, please refer to Tables 11, 12 and 13)	Development of low-flow installation criteria, site selection, installation. (pp. 121-122, Table 15)	Number of residences with Low-flow devices installed (p. 118)	Post-implementation monitoring, Survey septic violations, quantify water quality issue reduction, continuing maintenance, Halls Bayou ambient sampling (pp. 126-128)	Structural measures: EPA(funding), TCEQ (oversight), H-GAC (administration), EAMD (coordination of installation), HCPCID (coordination of installation), FWSD , TAMUG, HCPCT2 (Sec. 1.5.1) Behavioral Measures: EPA, TCEQ, HGAC(administration, outreach), EAMD (outreach), FWSD (outreach), HCPCT2 (outreach), TBH (outreach/education)(Sec. 1.5.1)

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Malfunction-ing OSSFs (16% of loading)	Sanitary Sewer System (mid-long term) (pp.-92-94,p. 95, pp. 98-100, p. 102)	100% reduction in bacterial load from malfunctioning septic systems when sanitary sewer system is installed, coupled with education and outreach. (p. 92, p.95, Appendix C)	Municipal Sewer System ($16 million)- Two possible providers - City of Houston(no plans to annex), FWSD (pp. 98-99, pp. 102-103)	Future educational efforts by Stakeholders on necessity of sanitary sewer. (pp. 110-111, pp.125-126 , Table 12)	Mid-Long-term (not currently scheduled) (all schedules, please refer to Tables 11, 12 and 13)	Completion of design/ feasibility studies for sanitary sewer, secure funding. (pp. 121-122, Table 15)	Inter-local signed, capacity and funding secured. Design completed. System Installed. (pp. 121-122, Table 15)	Post-implementation monitoring, Survey septic violations, quantify water quality issue reduction, continuing maintenance, Halls Bayou ambient sampling (pp. 126-128)	H-GAC: (coordination of WPP, dissemination of information) SAG (continued interaction with future service provider) FWSD (potential future service provider) EAMD (potential future service partner) TBH (potential future outreach) (Sec. 1.5.1)

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Unknown (34% of loading)	Will potentially identify and quantify unidentified bacteria water quality sources through future 319(h) grant or other in future phase(s) of the project if needs dictate.	It is estimated that some portion of the "unknown" sources are loadings from unidentified sources. This is not quantified at present, but some degree of load reduction is expected in conjunction with reductions of known sources. (Appendix C for general information on load reductions)	No funding is allocated for this task during this phase of the project.	It is assumed that some degree of the Unknown 34% is from unidentified sources. The education components for the known sources will overlap with this category to some degree. (Sections 7.4.2, 8.6)	There are no specific schedule items for this category.	There are no interim milestones for this management measure.	There are no indicators for this measure.	This category will be monitored in conjunction with the general pre- and post-monitoring that will take place for the other bacterial sources. (Section 8.7)	H-GAC – assessing need for future refinement of bacterial sources, grant/funding application, routine ambient monitoring and targeted pre-post implementation monitoring.

1.0 INTRODUCTION

The Westfield Estates Watershed Protection Plan (Westfield Estates WPP) provides a set of strategies to address water quality problems that have resulted from nonpoint source (NPS) bacterial pollution in the Westfield Estates Watershed (Watershed). Building on a common history of water quality concerns, previous studies, and identified issues, water quality monitoring results and Community involvement, the Westfield Estates WPP is a summation of the past and present efforts of its component stakeholders. It is intended to serve as a roadmap for the design and implementation of community-centric efforts to reduce bacterial contamination in the Watershed.

The Environmental Protection Agency (EPA) identified nine core elements that should be addressed by a Watershed Protection Plan (WPP). These elements are addressed over the course of this WPP, along with additional information regarding the history, character and future of the Watershed and community. This introductory section is a guide to navigating the Westfield Estates WPP, and provides a review of its history and development.

1.1 Plan Navigation-a Road Map

This WPP contains eight major integrated sections. A brief description of the content of these sections is given below. The relationship of these sections to the nine EPA WPP elements is demonstrated in Table 1.

Section 1 Introduction provides a management overview including a section road map to assist in navigating this document, a brief introduction to the watershed protection planning process and information regarding the historical development of this WPP.

Section 2 Watershed Characterization contains historical information about the Watershed, a current overview of the Watershed (demographic characteristics, economics, and political boundaries), a description of the physical and natural features (geography, natural areas, water sources, climate, and hydrology) and other plans in the Watershed.

Section 3 Water Quality Data Index provides a brief description of the applicable water quality standards and a recounting of the available monitoring and resource data collected by H-GAC and other agencies.

Section 4 Pollutant Cause and Source Assessment looks at potential point and nonpoint sources of pollution in the watershed.

Section 5 Linkage of Pollutant Loads to Water Quality is an estimation of pollutant loads calculated from current analytical data using the HSPF model.

Section 6 Goals and Objectives contains plan management objectives and load reduction targets, which will serve as benchmarks of the **Westfield Estates WPP**'s effectiveness after the implementation phase is completed and implementation objectives are identified.

Section 7 Management Strategies for Implementation provides a review of existing organizational structures, existing controls (structural and non-structural) and strategies needed to achieve plan goals.

Section 8 Implementation Strategy Design contains the design for the implementation phase of the **Westfield Estates WPP**. It provides an overview of management strategy, planned activities, roles and responsibilities, indicators of success, schedule of activities, interim milestones, estimation of time and technical assistance needed, information and education components, monitoring component, and an evaluation framework.

A list of **Acronyms, Figures,** and **Tables** are at the beginning of the Plan. **References** follow Section 8 along with several appendices. These include **Appendix A –Public Awareness and Education, Appendix B – Analytical Data, Appendix C – Modeling, and Appendix D - Implementation.**

1.2 The Watershed Protection Plan Model

A **Watershed** is a dynamic living system. The general definition holds that a watershed is "the area in which all water, sediments, and dissolved materials flow or drain from the land into a common river, lake, ocean, or other body of water."[3] The Westfield Estates Watershed is part of the San Jacinto River Basin. Flood control ditches and channels collect in the Watershed and empty into Halls Bayou, which in turn converges with Greens Bayou; thence to Buffalo Bayou, the Houston Ship Channel, and ultimately the Gulf of Mexico.

However, a watershed as a planning concept is more than the sum of its drainage characteristics. A more holistic description of a watershed incorporates the sum of its biological systems, local and regional stakeholders, political jurisdictions, and history that affect, and are affected by, a given drainage basin. A watershed is home to a diversity of living things inextricably linked by their common water source and its quality. A watershed knows no political boundaries. The physical connection of waterways within the watershed creates a unified system shared by all. Because a watershed runs down slope to its lowest point, changes in upstream activities affecting water quality, contaminant quantities or rate of movement can affect downstream locations. Therefore, water quality concerns in a watershed are inherently multi-faceted and regional in nature, requiring solutions of an equally comprehensive and regional scope. Good watershed management begins with defining common concerns, problems and desired results, and leads to a WPP developed by engaged and committed stakeholders.

[3] EPA. 2006. Wetlands and Watersheds. Retrieved on December 17, 2008 from http://www.epa.gov/owow/wetlands/facts/fact26.html.

A Watershed Protection Plan is a comprehensive document addressing water quality concerns in a watershed through a variety of evaluative practices, management measures and coordinated outreach efforts. It considers a variety of pollution sources, evaluates and recommends remedies, provides for the coordinated implementation of solutions, and assesses their success. The ultimate goal of a WPP is to serve as a framework for initiating and coordinating stakeholder-based watershed restoration initiatives. It is inherently a dynamic document, allowing stakeholders to integrate the demands of new circumstances, make modifications as dictated by interim results, and incorporate additional solutions and strategies as new issues arise.

A WPP addresses pollution from a variety of sources, recognizing the diverse activities that may occur in a given watershed. Sources of pollution in an urban watershed are divided into two primary categories: point source and nonpoint source.

Point source pollution is traceable to a discrete location such as the outfall of an industrial facility, small business, or a wastewater treatment plant that discharges directly into the water body. Most point sources must obtain permits from the State of Texas in order to discharge in to State waterways. The discharges are regulated under the Texas Pollutant Discharge Elimination System (TPDES). (There are no identified point sources in the Watershed.)

Nonpoint source pollution comes from a variety of locations and reaches waterways primarily through precipitation runoff or flooding. NPS pollution includes contaminants borne by runoff from lawns and agriculture (e.g. pesticides, fungicides, and fertilizers/nutrients), paved surfaces and highways (oil, grease, and trash), construction areas, malfunctioning OSSFs, pet waste, birds, and wildlife. (The bacterial contamination in Westfield Estates is due to nonpoint source pollution.)

In the Watershed the principle pollution issue is bacterial contamination from malfunctioning OSSFs, pet waste, birds, feral domestic animals, and wildlife. Bacteria levels in excess of State criteria also exist in Halls Bayou. Scientific analysis determined levels of bacteria exist in the Watershed in excess of State criteria for contract recreation. Outfall from the Watershed may contribute to bacterial contamination to adjacent area waterways. Additionally, several sections of Halls Bayou (1006D_01 and 1006D_02), a few miles downstream of the Watershed, were recently identified on the 2008 Texas State Water Quality Inventory-Basin Assessment Data List for total phosphate, orthophosphate and nitrate. The State of Texas, under the federal Clean Water Act, uses a watershed approach to develop programs and practice to improve, protect, and or restore water quality, which defines and evaluates the quality of surface waters in the State.

The WPP can be a complement to the total maximum daily load (TMDL) model development and program deriving its authority from Section 303(d) of the Clean Water Act. A TMDL establishes the maximum amount of a pollutant that a water body can receive and still attain and maintain its water quality standard. If a stream contains a pollutant above its allowable TMDL it is considered “impaired” and placed on the “303(d) List,” so named because of its authorizing legislation. A formal procedure ensues to develop and implement plans to address the pollution in the Watershed. A WPP can help achieve those goals while also incorporating other stakeholder concerns. This WPP will be consistent with the TMDL project for bacteria in the Houston Metropolitan Area and its Implementation Plan.

The advantages and benefits to using a WPP include (1) geographic focus based on hydrology rather than political boundaries, (2) objectives for water quality based on scientific data, (3) coordinated priorities with integrated systems, and (4) diverse, well-integrated partnerships.[4] This approach is well suited to the Watershed. The Watershed is within three different political jurisdictions, making coordination of management efforts crucial to WPP success. The WPP provides the community-based framework for coordination of these efforts.

1.3 Impetus for the Westfield Estates WPP

Findings from a series of studies (see section 1.4.1 for more detail) indicated that the Westfield Estates neighborhood has the highest need for public sewer services, and greatest potential for its residents to be exposed to waterborne pathogens from human and nonhuman sources, in the County. This collection of residential homes and small businesses is served solely by OSSFs, many of which appear to be malfunctioning.

Black, sewer-smelling water is found in ditches in dry weather (Refer to Figure 18 for site locations). Levels of *Escherichia coli* (*E. coli*) indicator bacteria well in excess of State criteria for contact recreation have been documented at many locations. Untreated human sewage from failing OSSFs flows directly into the linear ditches in front of the properties in the Watershed. Common reasons cited for OSSF failure include age and design of the system, soil type, small lot size, improper installation, or lack of proper operation and/or maintenance.

Many discussions have taken place between Harris County, the Sunbelt Fresh Water Supply District-Oakwilde (FWSD), the East Aldine Management District (EAMD), the Houston-Galveston Area Council (H-GAC) and Community stakeholders regarding how best to address the Watershed's malfunctioning OSSF issues. Millions of dollars are required to either repair the OSSFs or provide municipal sewer service to the Community. As with many urban communities without access to reliable sanitary sewer services, the Community lacks the tax base necessary to support needed services because of income levels and/or lack of economic development.[5] The economic burden for a permanent Community bacterial contamination solution is substantial (approximately $16 million according to Harris County Precinct 2's (HCPCT2) recent study, entitled *Unincorporated Revitalization Program Comprehensive Water & Wastewater Engineering*.) There is no single source of funding, which will cover the entire cost of the project. Possible sources of funding for the project, each with its own requirements, include:

- EPA State and Tribal Assistance Grants (STAG);
- Texas Water Development Board (TWDB) Economically Distressed Areas Program (EDAP);

[4] Texas Commission on Environmental Quality. 2006. Preserving & Improving Water Quality. Texas Commission on Environmental Quality, 9/06 GI-351. Austin, Texas.

[5] U.S. Census. 2000.

- Housing and Urban Development's Community Development Block Grant (CDBG) Program;
- TWDB Water Supply and Wastewater Facilities Planning Program;
- Department of Commerce Public Works Economic Development Program;
- TWDB Clean Water State Revolving Loan Fund (SRF) Program;
- TWDB State Loan Program Texas Water Development Fund II;
- TCEQ Supplemental Environmental Projects (SEPs); and TCEQ 319(h) grants

According to Watershed leaders and elected officials, it is unlikely that suitable funds will be available to provide municipal sewer service to residents in the Watershed in the next few years. EAMD and the FWSD are currently studying the ability to expand capacity at a local wastewater treatment plant to serve communities in the area. The next steps toward this ultimate goal would be a study of the feasibility, and design, of a collection system for the Community when funding was secured. While the timelines for this process have not yet been fully quantified, final installation of a sanitary system is still expected to be at least 4-5 years away. Interim solutions to bacterial contamination from malfunctioning OSSFs and other sources will be necessary, but must be coordinated with the long-term solution in mind. Because of different grant and loan requirements and jurisdictional issues, an active stakeholder group will be necessary. Application coordination and support will also be needed, especially where matching funds are required. Additionally, community outreach will be necessary so that residents embrace the sanitary sewer system when it becomes available. H-GAC will act as coordinator for all outreach activities and for the stakeholder group throughout this phase of the Plan's implementation.

In order to secure funding from any source, the magnitude of the bacterial water quality issues had to be quantified. In 2006-2007, H-GAC, with funding from the Galveston Bay Estuary Program (GBEP), completed a determination of bacteria levels in ditches and at several locations in Halls Bayou. The study included a preliminary human health risk assessment. These results were presented to the Watershed's residents at a Town Meeting in early 2007. Citizens raised additional concerns about flooding issues which were added to the Westfield Estates WPP scope. Currently, flooding issues are being addressed by other efforts of the HCPCT2 and HCFCD.

In 2007, HCPCT2 completed another Precinct-wide assessment of options to address water and sewer needs. One of the options presented for the Watershed was to provide municipal sewer service to the Community. With an estimated cost of $16 million the option was not considered economically viable at the time. An interim solution, which included remediation or replacement of malfunctioning OSSFs coupled with a required maintenance agreement, was considered a reasonable alternative option. These interim solutions to the malfunctioning OSSF issue, including both management programs and public education and outreach, were proposed to the citizens.

However, this historically underserved community had prevailing concerns about the initiative, based on the inability of previous efforts to adequately address the issues. Additionally, major stakeholders did not want to propose another plan without some measure of guaranteed funding. A continued focus on building trust and fostering relationships with the residents and local stakeholders will be crucial to the successful implementation of the Westfield Estates WPP. The

analysis, knowledge, and experience gained in the local Community will be crucial in developing and implementing successful strategies for managing the Watershed.

Recognizing the acute bacterial issues of the Watershed, and the benefits of a WPP in addressing them, the proposed solutions have been put forth in the form of the **Westfield Estates WPP**. The stated mission of this WPP is to reduce the levels of bacteria in the Community and adjacent Halls Bayou and institute management practices and stakeholder commitment to prevent future degradation of water quality. A successful WPP, which addresses the OSSFs, nonhuman bacteria sources, and other general concerns of the residents concerning follow-through, will be a key towards the renewal of this once vibrant community.

1.4 Development of the Westfield Estates WPP

1.4.1 Prior Efforts

Bacterial contamination of waterways in the H-GAC region has been a concern for some time. Over the last decade, specific concern has also grown in relation to the concentrated bacterial contamination in Westfield Estates and surrounding areas. The efforts that lead to what would eventually be the Westfield Estates Phase I study, and subsequently this WPP, were:

- In 1999 H-GAC examined 25 communities in the area presumed to be contributing untreated human sewage to area waterways via malfunctioning OSSFs.[6] Funding was not available to address the issues in any of the communities.

- In 2004-2005, HCPCT2 commissioned an assessment of wastewater treatment needs within the Precinct, which contained the highest concentration of septic system violations in the county.[7] Westfield Estates was identified as the community with the most critical need and the highest number of OSSF violations.

- In 2005, a subcommittee of H-GAC's Natural Resources Advisory Committee (NRAC) began meeting to address malfunctioning OSSF issues with renewed interest. The committee was comprised of representatives from county and local government, environmental groups, professional engineers, H-GAC, and GBEP.

- In 2006, HCPCT2 commissioned an assessment of alternate solutions to providing wastewater treatment to homes in the Precinct, including those in the Westfield Estates Watershed. [8]All options were considered cost prohibitive at the time because the Community/residents within the Watershed lack resources or lack the tax base to support funding of the options.

[6] H-GAC. 1999.
[7] HCPCT2. 2005
[8] HCPCT2. 2007

1.4.2 Westfield Estates Phase I Study

In 2006-2007 H-GAC conducted a Failing OSSF Initiative (referenced herein as Westfield Estates WPP Phase I, or Phase I Study) in the Watershed.[9] The Phase I study assessed environmental water quality issues associated with bacterial contamination in Westfield Estates Watershed and looked at potential human health risks. Funding for the project was the result of a partnership between the H-GAC and the GBEP, performed with support from HCPCT2. The Westfield Estates Watershed Phase I study showed:

- Bacterial contamination by the pathogen predictor of *E. coli* is above State of Texas standard for contract recreation in all standing water in ditches in Westfield Estates Watershed;
- Bacterial levels at half the sampled locations (ditches in the Watershed) are in a range that has been demonstrated to pose an elevated risk to human health (>100,000 MPN/100ml);
- Bacterial levels in samples taken from adjacent Halls Bayou are above State standards in many cases;
- Sources of bacterial contamination are from both human and nonhuman sources (dog, chicken, and unknown), using Carbon Utilization Profiles;
- Additional work may be needed to quantify human illness through epidemiology studies, identify unknown bacteria sources with DNA testing, and apply data to TMDL studies;
- A permanent infrastructure solution is expensive ($16.2 million) and will take several years to develop;
- Interim solutions to the contamination Westfield Estates WPP (e.g. BMPs) could be developed;
- Issues will best be addressed by a group of stakeholders and partnerships through a WPP;
- A Watershed Town Meeting with over 100 in attendance showed high interest in addressing issues in the Watershed, and
- Sustained public outreach to the Community at large will be necessary to support a WPP and management strategies.

The Phase I study identified education and public outreach as being critical to the success of this project. In a historically underserved community where previous efforts have not adequately addressed concerns, credibility must be established and maintained. Resident participation in the Phase I town meeting was excellent and interest remains high.

[9] H-GAC. 2007

A stakeholder group of elected officials with jurisdiction over the Community was established (see Section 1.5). Residents will be actively engaged in the continuing development and implementation of the Westfield Estates WPP, and kept apprised of project process/progress.

1.4.3 Westfield Estates Watershed Protection Plan

In October 2007, H-GAC submitted a successful grant application for addressing bacterial implementation to TCEQ. In April, 2009 a contract was formalized in the form of an Inter-Governmental Cooperative Agreement with the TCEQ. These agreements are the basis for the design and implementation of solutions for the Westfield Estates community, as represented by this document.

This iteration of the WPP is Phase II (Phase I being the study referenced in section 1.4.2) of the watershed protection efforts for Westfield Estates. However, while it will refer to Phase I, this document represents the formal WPP for this watershed and should be taken as a stand-alone document. This phase is the culmination of these prior efforts and community feedback, and represents an implementation plan for addressing bacterial contamination in Westfield Estates through a variety of organizational, structural and behavioral BMPs. Goals for the second phase of the Westfield Estates WPP (Phase II) involved securing funding, designing and implementing corrective measures, and developing Community acceptance of the WPP. Public outreach will educate residents on the proper maintenance of OSSFs, and involve them in the development and implementation of BMPs for nonhuman bacteria sources.

Phase II objectives include:

- Investigate funding with TCEQ
- Implementing a program designed to eventually repair, install, replace, or provide maintenance to 150 - 200 eligible OSSFs, including maintenance agreements with FWSD;
- Install low-flow devices where feasible to supplement OSSF remediation by reducing flows to OSSFs;
- Develop and implement BMPs for nonhuman bacterial sources (e.g. pets and domestic animals);
- Town meetings three times per year to share progress;
- Final town meeting "wrap-up" and transfer to stakeholders group;
- Education for care of OSSFs; and
- Estimate of human health issues associated with malfunctioning OSSFs before/after project.

1.5 Public Participation and Outreach

Throughout the various efforts that have lead to the development of this WPP, the agencies involved have pursued a strong course of public involvement and community engagement.

1.5.1 Watershed Management Team

Watershed planning is a collaborative process. The Watershed Management Team, in this WPP called the **Stakeholders Advisory Group (SAG)**, is an interdisciplinary team comprised of local stakeholders, many with professional backgrounds, who provide resources and technical assistance for watershed-based planning, understanding of environmental and economic benefits, assistance in process streamlining, and expertise in sound environmental policy and procedures. The team also has members who represent the interests and input of the Community on an equal basis with the technical staff. Many of the Team members have worked together on other projects and have developed a trust that leads to efficient and honest communication between stakeholders.

The SAG is responsible for oversight on the development and implementation of the WPP. Because of the small geographic area covered in the Westfield Estates WPP, specific work groups are not required. The SAG breaks into smaller ad hoc groups of two or three persons to address certain technical issues as the need arises.

The SAG will meet at least quarterly during the course of the project, although they may meet more frequently as the project comes on line. H-GAC is represented on the SAG and provides administrative staff and a project manager for the implementation phase of the Westfield Estates WPP and related outreach activities.

Fostering partnerships and relationships between stakeholders is necessary to quantify, analyze, and develop successful strategies to resolve bacterial contamination in the Community. Partners and/or stakeholders include TCEQ Region 12, HCPCT2, Camp, Dresser & McKee, Inc. (contractor for Precinct 2 in the study, *Preliminary Findings in the Unincorporated Area Revitalization Program Needs Assessment*), Harris County Departments (Public Infrastructure, Public Health & Environmental Services, County Attorney), EAMD, FWSD, Hygeia Laboratories, Texas A & M University Galveston, GBEP, Lonestar College, and Community residents with an interest in increasing understanding of Community dynamics and bacterial nonpoint source pollution.

In addition to SAG participation, the following key stakeholders have committed to supporting specific WPP activities:

East Aldine Management District (EAMD): Installation of new OSSFs, repair/maintenance of salvageable systems, development of maintenance agreements.

Galveston Bay Estuary Program (GBEP): Funding and support for Westfield Estates WPP Phase I, needs survey in the Community, a portion of related inspections, applicant intake and qualification, public outreach, stakeholder group formation, and support.

Harris County Precinct 2 (HCPCT2): Report identifying overall Community need and priority within the precinct, public outreach and education in English and Spanish, meeting space, public awareness for community outreach, Spanish translation of materials and presentations, dissemination of outreach material, support for plans to implement BMPs, support for plans for a permanent solution to bacterial contamination in the Community and other parts Precinct 2, and sharing data collected in the Watershed from County sources.

Harris County Public Infrastructure Department (HCPID): Develop inspection criteria and forms, inspect representative number of lots for OSSF issues, develop rehabilitation plans, provide home qualification criteria and qualify homes for grants in this program, mail notification of inspections.

Houston-Galveston Area Council (H-GAC): Project administration and management (Phase I, WPP, and Phase II implementation); ambient water quality sampling; public outreach and education; and development of maintenance plan.

Sunbelt Freshwater Supply District - Oakwilde (FWSD): Public Outreach, mail outs to residents and stakeholder organizations in the Community, management of OSSF maintenance agreements with owners of remediated OSSFs.

Talento Bilingue de Houston (TBH) will provide volunteers and outreach support for events and publicity. As TBH is a newly added participant, the extent and value of their contributions has not yet been quantified, but will be included in subsequent updates to the Plan. TBH is an environmentally-oriented Latino outreach group who will be helping H-GAC design and implement an effective outreach program for the Latino community in the Watershed.

Texas A&M University–Galveston (TAMUG): Technical advice on nonhuman bacteria and pathogen source identification.

TCEQ Region 12 (TCEQ): Provides regulatory guidance and administration of federal grant and funding through the state water quality management plan.

Once the implementation phase is completed, SAG will pass its oversight role to a permanent stakeholder group (PSG) to maintain WPP achievements and plan for future long-term solutions and funding.

1.5.2 Prior Public Participation/Outreach Efforts

Input from people who live, work, and play within the Westfield Estates Watershed is critical to understanding the wide spectrum of activities that could threaten community and watershed health. It also assists in determining the important issues and concerns that resonate with the local watershed community.

Local knowledge played an important role in identifying possible sources of malfunctioning OSSFs, changes in drainage patterns, and flooding along the Watershed. This information guided the development of interim and final solutions, and served as a basis for securing project

funding. Individual interviews in the field, at "roundtable" discussions, and at public meetings readily identified bacterial pollutant loading hotspots within the Watershed. This increased understanding of the high value local residents and elected officials place on Community health and the natural resources of the Watershed. This set the stage for developing a Correction Strategy that will be supported at the local level. Gaining the trust of residents and local officials is essential to sharing local knowledge.

H-GAC, in collaboration with the SAG, began the initial outreach, education, and involvement program in 2006 to increase awareness about the extent of bacterial contamination in the Watershed. This effort included presentations at a variety of venues including the FWSD monthly Board of Director's meetings, the Westfield Estates Watershed Town Meeting, the GBEP State of the Bay Symposium, H-GAC's NRAC, local elementary schools, and others. A summary of activities (2006 – present) with dates, participants, and results achieved are included in Appendix A-Public Awareness and Education. Key aspects of the program included:

- Hosting public meetings;
- Conducting interviews with local citizens, elected officials, and resource agencies;
- Distributing informational brochures on proper care and maintenance of on-site wastewater treatment systems;
- Developing a resource CD on OSSF installation, maintenance, regulation, research, funding for remediation and contacts for further information;
- Distributing Bacteria in our Bayous brochure (in English and Spanish)
- Continuing an Education/Outreach campaign in local elementary schools (5th grade).

Openness and transparency are important aspects of the continuing education/outreach program. Methods for announcing public meetings included: 1) sending meeting notices and agendas to elected officials, interested citizens, county agencies, and utility district board members; posting meeting announcements at the local community center, faith-based organizations, the local grocery store, professional realtors and other businesses, 2) issuing press releases from HCPCT2, FWSD, and H-GAC, and 3) articles submitted to and published in local papers and newsletters (English and Spanish).

Meeting announcements, attendance rosters, and other meeting materials have been submitted to GBEP via project progress reports. Public meetings were held at least semi-annually. A monthly progress report was posted at the community center for town meetings. (See Appendix A-Public Awareness and Education for dates and a town meeting summary.)

H-GAC also provided a results summary and risk assessment to the Community in both English and Spanish. Modes of distribution included public meetings, local outreach events, and inserts enclosed with water bills. H-GAC also worked with the HCPCT2 elected officials and staff to provide additional copies to persons who expressed an interest in distributing copies through their various communities. H-GAC will also prepare a short summary of this WPP in Spanish and English for dissemination to the public.

To raise awareness of the importance of proper OSSF maintenance and improve the community knowledge base, H-GAC developed and updates an OSSF CD, which includes considerations,

solutions and resources for individual homeowners in the Watershed. Much of the material is available in Spanish.

2.0 WATERSHED CHARACTERIZATION

The Westfield Estates Watershed is a small, urbanized watershed in Harris County, Texas. This section provides a comprehensive description of the spatial, environmental, and socio-political character of the Watershed and its component communities and natural features. The following figures demonstrate the spatial relationship between the Greater Harris County/Houston Metropolitan Area and the Watershed's location, in increasingly smaller scale.

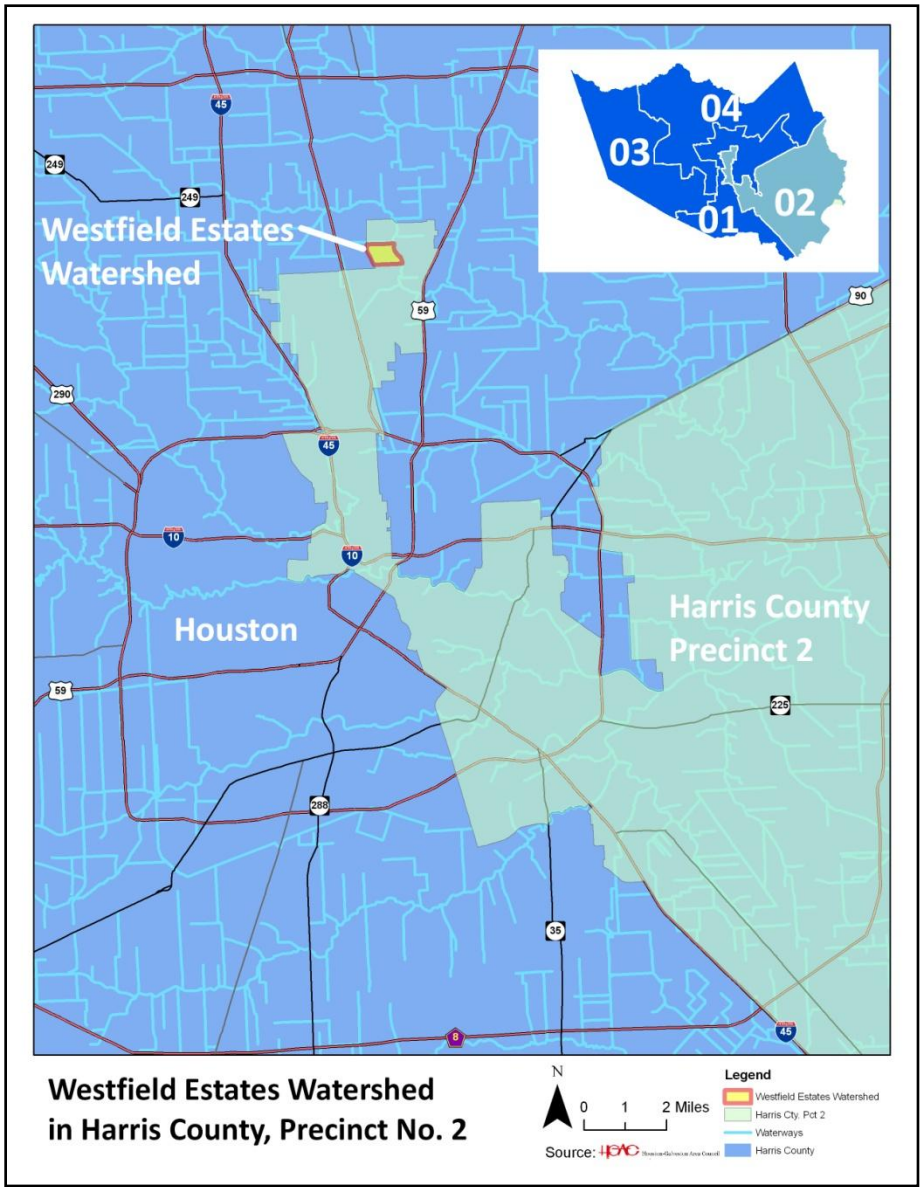

Figure 1: Westfield Estates Watershed in Harris County

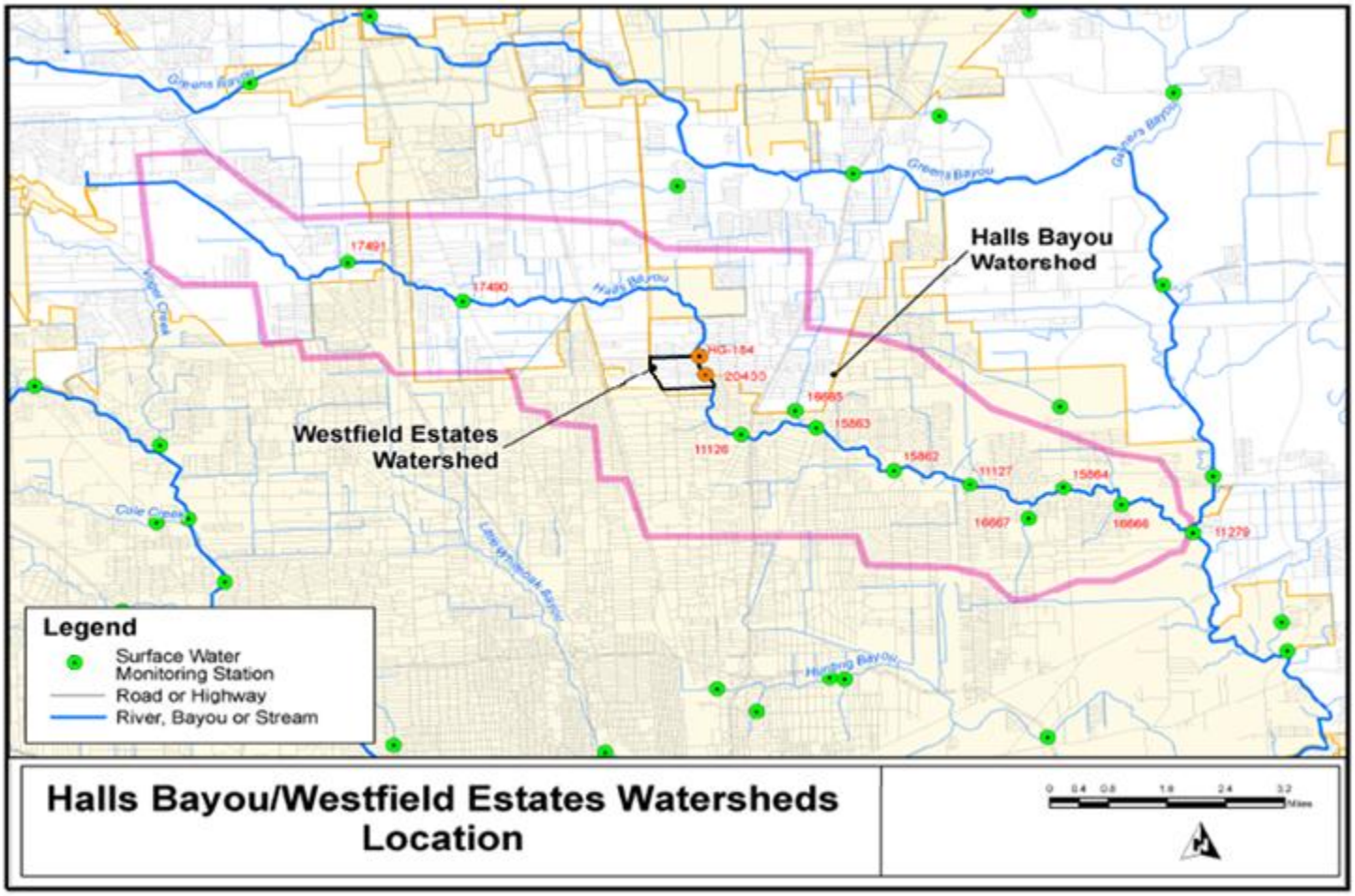

Figure 2: Westfield Estates Watershed in Halls Bayou Watershed

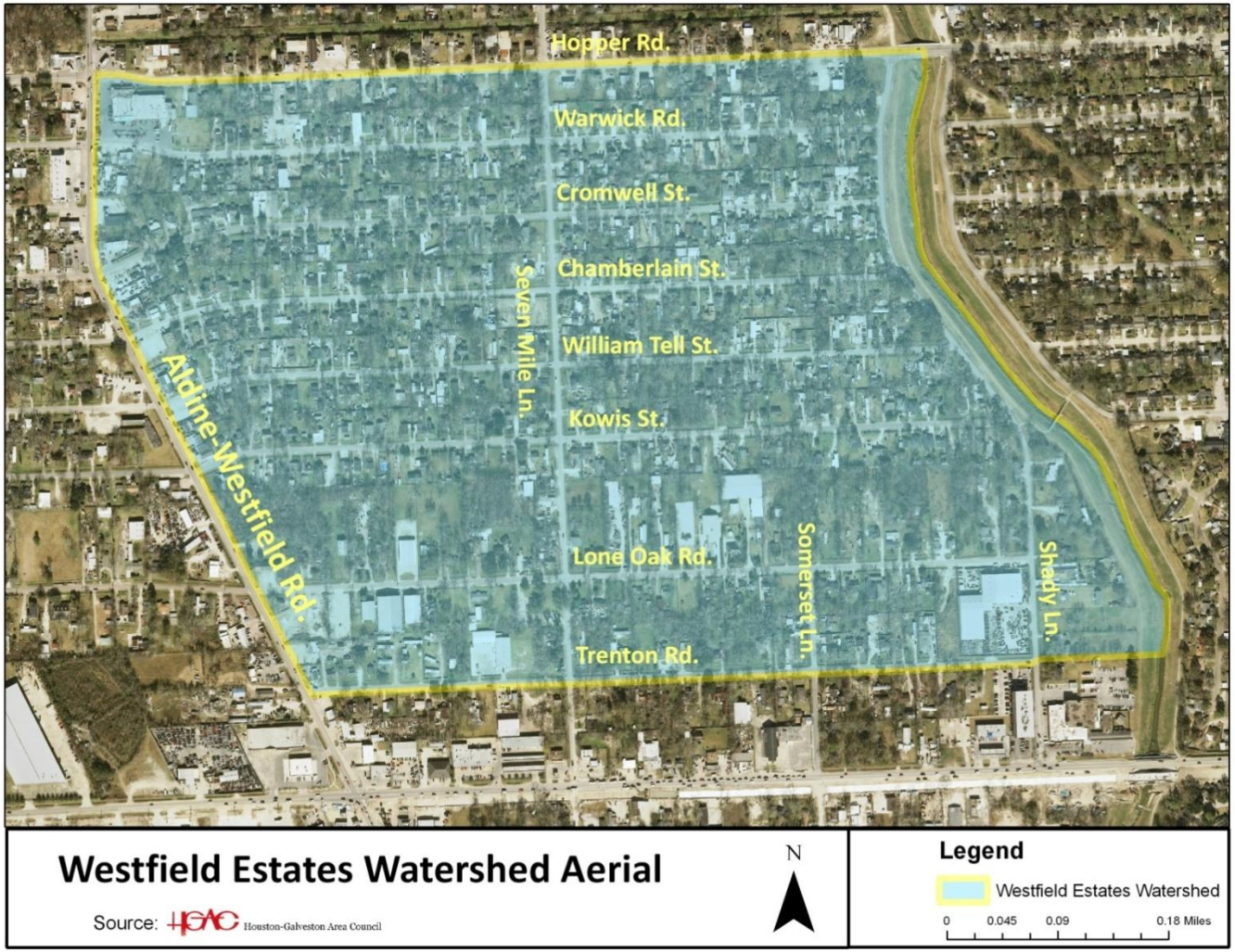

Figure 3: Westfield Estates Watershed – Aerial View

2.1 History

The Watershed was originally comprised primarily of single-family houses developed in the 1940s. The houses were, on average, less than 1,000 square feet with a median lot size (7,065 square feet) usually large enough for conventional OSSFs (Figure 4). Although Houston grew up around it, the Watershed was never annexed, remaining part of unincorporated Harris County and without municipal wastewater treatment service. Listed by the state as a "Texas Landmark and Vanishing Community," Westfield Estates is not to be confused with a similarly named new project in Katy, Texas. Over the intervening years, the composition of the Watershed has changed to reflect increasingly urbanized developmental patterns around it, as Houston has expanded and infill has occurred inside and around the Watershed. What were solely single-family residential lots with minor commercial activity have changed through subdivision of lots and increasing internal businesses (primarily car repair and construction related). The gradual decrease in economic status of the Community and normal aging of infrastructure has lead to widespread OSSF malfunctions and generally degraded conditions in the ditches and surrounding land of the Watershed.

Figure 4: Westfield Estates in the 1950s
(Source: Unknown)

2.2 Current Status

The status of the Watershed has changed considerably over the decades since the original development of its namesake Community. The majority of the Watershed's area is still occupied by a portion of the Westfield Estates Community. However, the Community is now an economically-distressed, urbanized community of single family or multi-family lots and of some mostly small-scale commercial, light industrial and institutional uses.

The Watershed drains to Halls Bayou, a tributary of Greens Bayou. It is currently located within the City of Houston's extra-territorial jurisdiction in an unincorporated portion of HCPCT2 in north-central Harris County (as shown previously in Figures 1 and 2). The boundaries of the Watershed are as follows: Halls Bayou on the east, Trenton Road on the south, Aldine-Westfield Road on the west, and Hopper Road on the north (see Figure 3).

While the Community extends west to the Hardy Toll Road, it is bisected by Aldine-Westfield Road, which runs roughly north to southeast. On several site reconnaissance visits, no connection in the form of drainage infrastructure crossing Aldine-Westfield could be found between the west half of the Community and the east half. These findings were confirmed with the Precinct and The Harris County Flood Control District (HCFCD). Therefore, the maps in the figures which follow delineate the Watershed with Aldine-Westfield as the western boundary (see Figure 5). The pollutant load evaluation and modeling discussed in latter sections reflect this distinction.

The streets within the Watershed are paved asphalt with many needing repair. The drainage ditches are similarly in need of repair. Approximately half of the homes are located within the 100-year flood plain and a few are located in the 10-year flood plain[10]. There are a few small parcels of undeveloped land throughout the Watershed. Impervious surfaces cover 40-50% of its total area, as is typical for urban watersheds. While traditional agricultural uses are not found in the Watershed, a number of residents in the Community do raise some agricultural fowl and animals, including chickens and a few goats. There are significant numbers of feral dogs, cats and some feral chickens. The domestic and feral animals represent a significant source of bacteria in the local ditches.

The current land use in the Watershed is typical of urbanized watersheds (see Figure 6). Population growth, land redevelopment and gentrification within Watershed show a rise in the number of OSSFs, higher traffic levels, more trash and litter, and replacement of open space with impervious cover. As a result, Harris County believes that residential and urban nonpoint bacterial source loads have become a proportionately larger source of water quality degradation in the Watershed. Growth and development, combined with an increase in contact with watershed waters associated with that growth and intermittent but persistent flooding, could pose an increasing risk to human health and public safety, and impair the recreational use of watershed water bodies.

[10] 10-year Floodplain - 10 percent chance of flooding in a single year or 95% chance of flooding in a 30-year mortgage.

Based on the character of the Watershed and the increasing public and environmental health risk represented by bacterial contamination, it is essential for residents, Community leaders and elected officials to be proactive in addressing this issue using avenues such as this WPP to achieve goals.

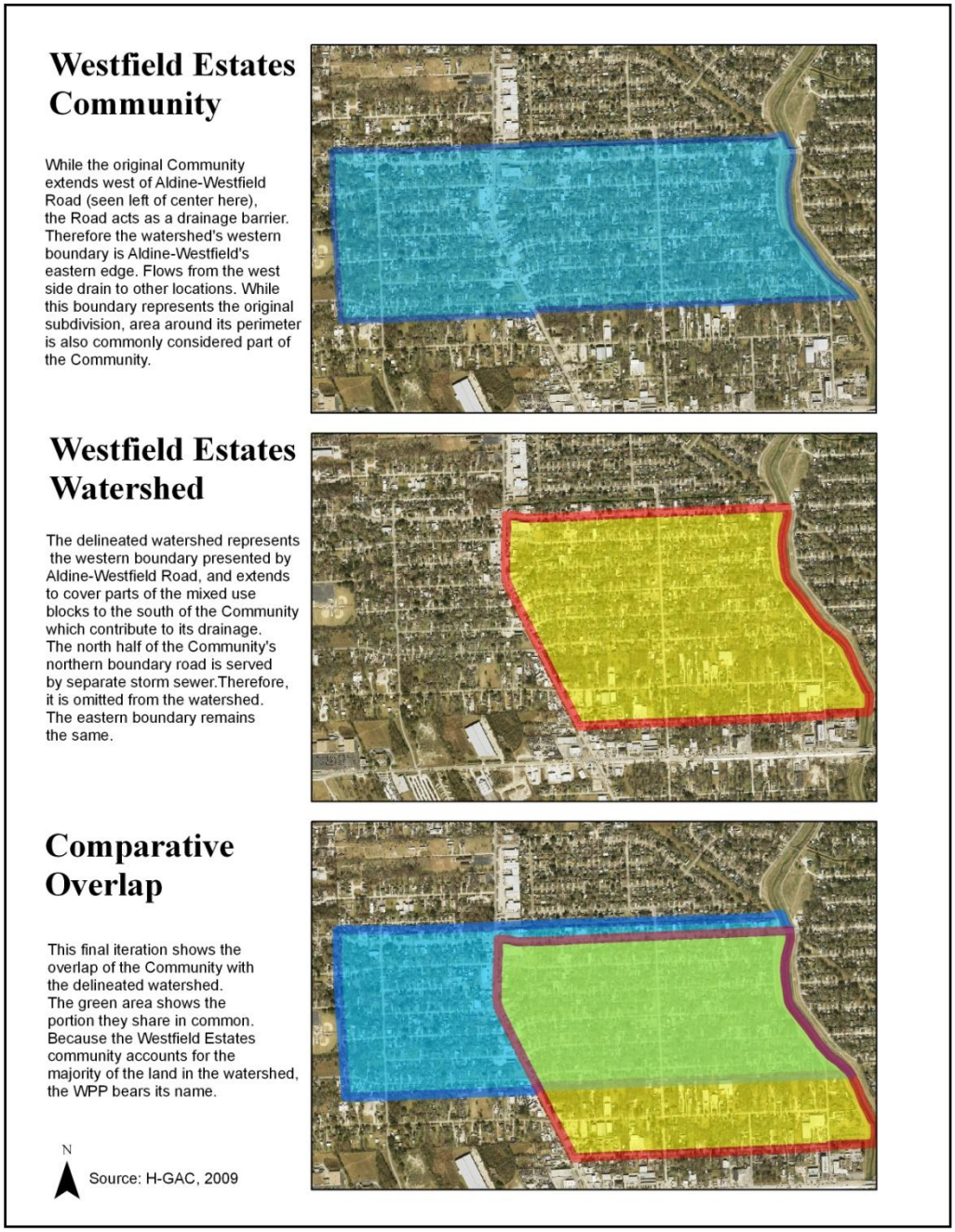

Figure 5: Comparison of Westfield Estates Community and Westfield Estates Watershed
(Map source: H-GAC, 2009)

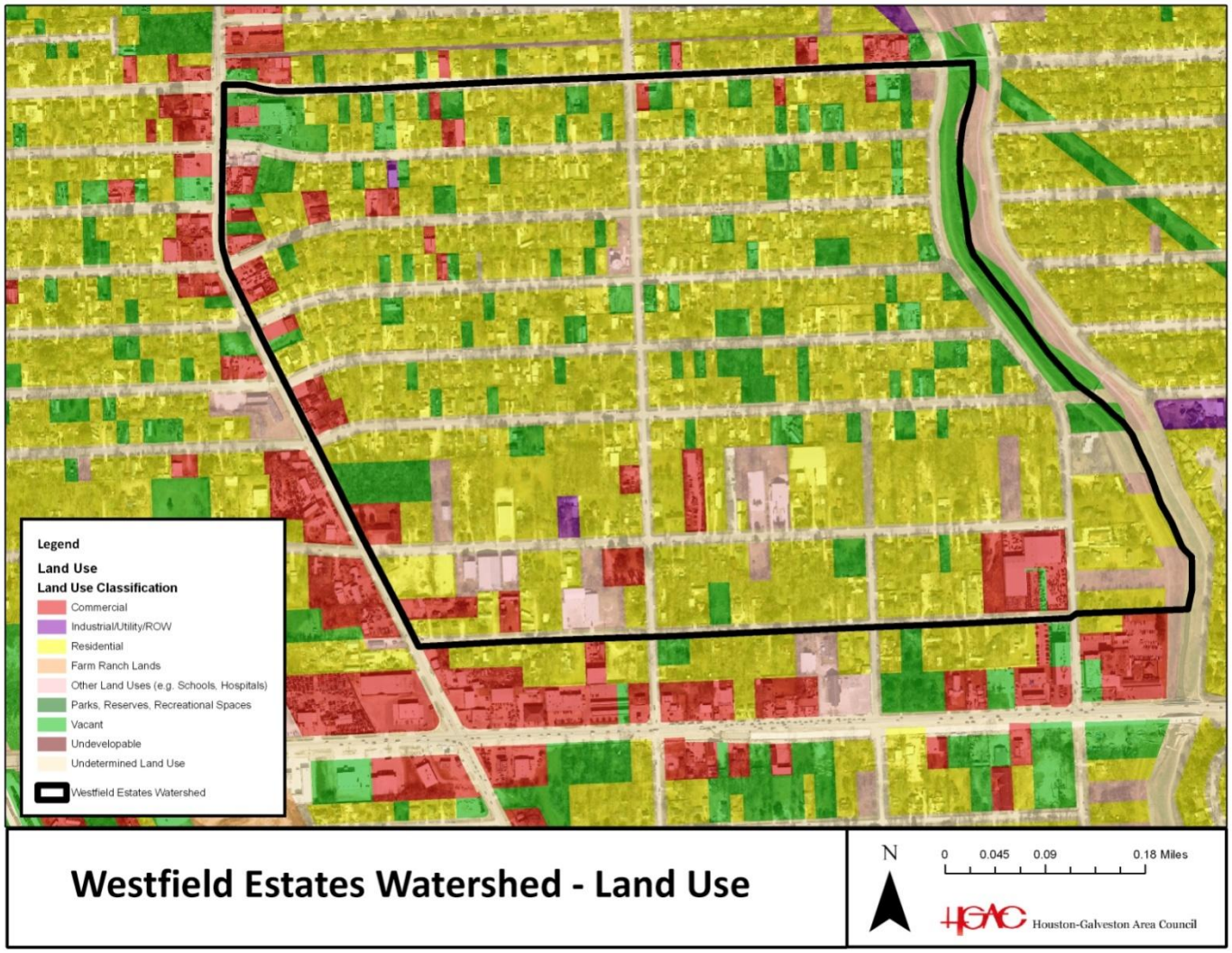

Figure 6: Land Use in Westfield Estates Watershed
(Map Source: H-GAC, 2009)

2.2.1 Demographic Characteristics

The population is evenly distributed throughout this urban, residential community. Westfield Estates proper is comprised of over 450 homes, 20 small businesses (machine shops, automobile repair facilities, etc), several churches and the George Foreman Boxing Club. Approximately 1900 people currently live in the Watershed.[11]

According to the 2000 U.S. Census, the Community of Westfield Estates has a higher proportion of minorities, disabled, less-educated, foreign-born, non-English-speaking, and lower income populations and a higher than average family size than Houston as a whole, Texas, or the U.S. Census data show 22% of the population in Westfield Estates lives below the poverty level, 43% are disabled, 67% have not graduated from high school, 75% are non-white, 37% are foreign born, and only about half speak English at home (Table 2). This area's demographic profile is strikingly different when compared to those for Houston, the State of Texas, and the U.S. (Table 3).

Table 2: Westfield Estates Demographics – 2000 U.S. Census

Category	Population 1 *	Population 2 **	Population Total	Percent of Total (%) ***
2000 Census Tract	221900	221900		
2000 Census Block	2	3		
Total Population	1181	1763	2944	
65 or older	69	133	202	7%
White	386	324	710	24%
African American	25	49	74	3%
Hispanic	765	1390	2155	73%
Other	5	0	5	0%
Average Family Size	3.7	3.65	3.68	
High School or higher diploma	255	245	500	33%
Disability	628	648	1276	43%
Foreign Born	327	765	1092	37%
Residence (owner occupied) Median Value	$36,600	$40,100	$38,350	
Language other than English at Home	547	1109	1656	56%
In Labor Force	441	545	986	48%
Household Income (Median)	$26,739	27,039	$26,889	
Families below Poverty Level	213	445	658	22%

* 2000 Census Tract 221900 Block 2.
** 2000 Census Tract 221900, Block 3.
*** Percent exceeds 100 percent because population may appear in more than one category.

[11] U.S. Census, 2000.

Table 3: Comparative Demographics - 2000 U.S. Census

Demographic	Westfield Estates	Houston	Texas	U.S.
65 or older	7%	8%	10%	12%
White	24%	31%	52%	69%
African American	3%	24%	11%	12%
Hispanic	73%	38%	32%	13%
Other	5%	7%	4%	6%
Average Family Size (Number of persons)	3.68	2.67	2.45	2.33
High School or higher diploma	33%	43%	71%	78%
Disability	44%	33%	30%	32%
Foreign Born	37%	27%	14%	11%
Residence (owner occupied) Median Value	$38,350	$78,100	$51,600	$70,600
Language other the English at home	56%	38%	29%	17%
In Labor Force (18 or older)	48%	48%	57%	61%
Household income (Median)($)	$26,889	$36,501	$31,039	$33,125
Families Below Poverty Level	22%	19%	17%	14%

According to 2000 U.S. Census data, 37% of the population of the Community is foreign born and only half speak English at home. This necessitates the development of outreach materials in Spanish as well as English, the use of a translator at all activities (especially Town Meetings) and projecting presentations simultaneously in English and Spanish. An emphasis of outreach through public school curriculum and other materials in support of this WPP is desirable.

2.2.2 Economics

Home values in the Watershed have risen rapidly in the last ten years, from a value of $21.68 per square foot in 1994 to $58.59 per square foot in 2005. The median market value in 2005 was $43,000. Several new homes were listed in 2007 in excess of $100,000. The rise in home values has resulted in some gentrification as well as an opportunity for repair and reinvestment in the Community.

Over the years, the residential character of the Watershed has changed. Original single residence lots have been subdivided and contain multiple houses, trailers, and/or manufactured homes. Thus, in some cases, adequate area for an OSSF no longer exists. In other cases, OSSF facilities were not installed with the lot division and untreated sewage flows directly into county ditches in front of the properties and ultimately into Halls Bayou via the drainage system.

In still other cases, current OSSFs cannot manage the increased flow from multiple residences tied to a single-sized original OSSF. It is estimated that fifty percent of the residences have either malfunctioning, inadequate, or no OSSF.

Many homes in Westfield Estates have deteriorated because of deferred maintenance. These observations, coupled with visible evidence of discharges, have lead to the presumption that the

OSSFs have not been maintained either. This is indicative of WPPs arising in a community where 22% of the population lives below the poverty level according to 2000 U.S, Census data. Several locations in the Community exhibit characteristics of malfunctioning OSSFs. Stagnant black-colored water is found in ditches during dry weather from which a strong "sewer" odor emanates, causing residents to voice concern about the raw sewage in their ditches. They have hoped for many years that the sewage treatment problems would be corrected. One of the difficulties in finding permanent reliable sanitary sewer services for the Watershed is that it does not have a sufficient tax base to support needed services due to lower income levels and/or lack of economic development. Thus, the Westfield Estates WPP interim solution provides a viable option to reducing bacterial water quality issues in the Watershed.

2.2.3 Political Jurisdictions

The Watershed is located in **HCPCT2**, an area in which many malfunctioning OSSF violations have been recorded. HCPCT2 recently completed a study identifying the needs and approximate cost of providing sewer service to Westfield Estates. The report estimates that approximately $16 million dollars is needed to provide the service. Commissioner Sylvia Garcia has pledged support to the project and is exploring funding options. HCPCT2 remains an integral part of the watershed outreach program.

In 1996 the **TCEQ**, then called the Texas Natural Resources Conservation Commission, was instrumental in the formation of the FWSD, which provides water and/or wastewater service to a number of unconnected communities in Harris County, including most of the Westfield Estates Watershed.

The **FWSD** completed installation of potable waterlines to most of the Community through a Community Development Grant from Harris County in 2006. FWSD was formed by directive from the TCEQ to address suburban water needs in five non-contiguous communities in Harris County. It has seven thousand connections, three water plants, and five sewage plants. Most communities are served with water and sewer, some with water only, and some with neither. FWSD has committed $15 million in funds from a variety sources, including community block grants to improve service within its jurisdiction. One of FWSD's communities, called Oakwilde, includes the Watershed (Figures 7). There are approximately 1,900 subdivision plots in FWSD-Oakwilde, 60% served with water and sewer, and 40% served with water only. The FWSD has no authority to levy taxes, either for construction of facilities or maintenance, and all its services are fee based. The FWSD has limited legal authority to raise capital for the municipal sewer project needed for Westfield Estates and cannot require residents to connect to the system when completed.

The Watershed is also located within **EAMD** and **Aldine Independent School District** (Figure 8). The East Aldine Management District is a governmental entity "…created by the Texas Legislature in June 2001 to enhance the physical, social, and economic well being of the Aldine community."[12] EAMD is working with local service providers like the FWSD to expand and improve water and wastewater service in the area surrounding the Watershed.

[12] As retrieved from http://www.aldinedistrict.org/, on 3/24/10.

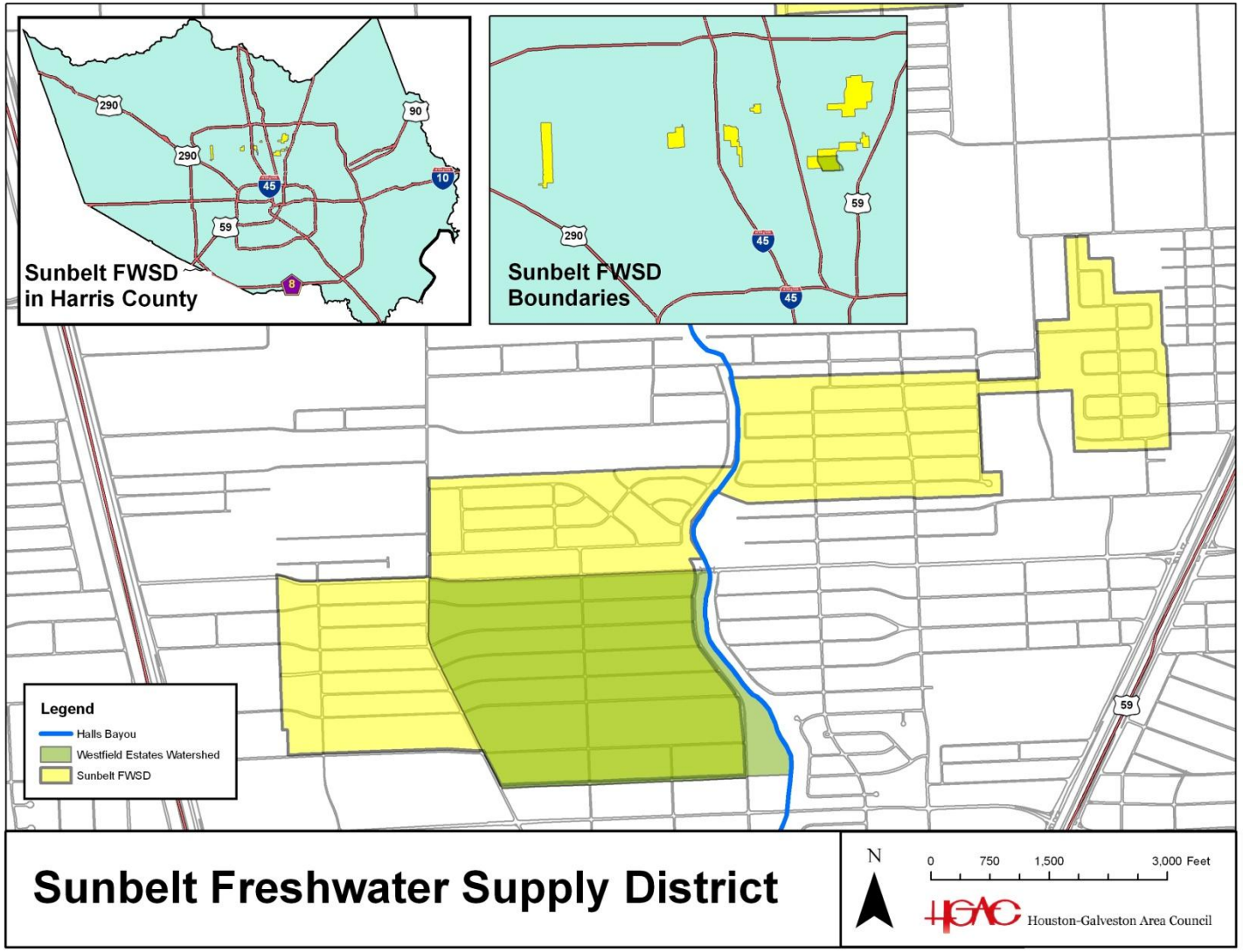

Figure 7: Political Boundary of Sunbelt Freshwater Supply District
(Map Source: H-GAC, 2008)

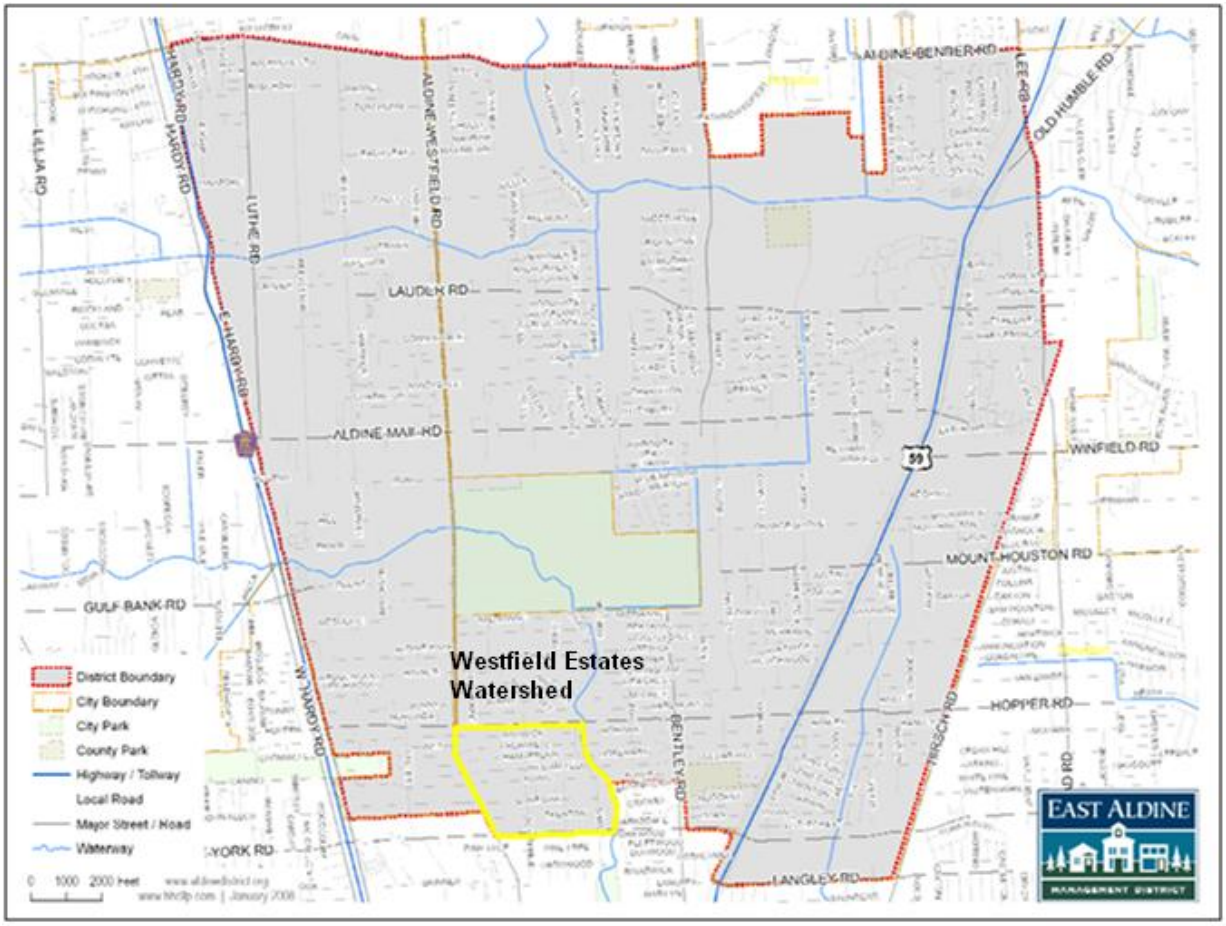

Figure 8: East Aldine Management District
(Source: East Aldine Management District, the Watershed is shown via the yellow rectangle)

2.3 Physical and Natural Features

2.3.1 Watershed Geography and Soils

The Watershed consists of a series of linear drainage ditches with congregated outfall structures that discharge into Halls Bayou. The outfalls for the Watershed are on the west bank of Halls Bayou, a tributary of Greens Bayou. Greens Bayou is a tributary of Buffalo Bayou, which flows into the Houston Ship Channel, and thence into Galveston Bay and the Gulf of Mexico. (See Figure 9)

The Watershed is located in the Gulf Coastal Plain, which is characterized by a hydrology of slow moving streams and poorly drained soils. There are two predominant soil types in the Watershed: Harris Clay and Kenney Urban-land complex (as shown in Figure 10). These Type/Class IV soils have severe limitations that restrict the choice of plants and/or require very careful management. Clay soil is tightly bound and provides poor drainage. Thus, conventional septic systems which require filter beds are not good choices for this type of soil.

2.3.2 Natural Areas, Habitat, and Wildlife

According to the Texas Almanac, Westfield Estates is located in the Gulf Prairies and Marshes vegetational area, which is a nearly level plain that used to cover an area of 13 million acres bordering the Gulf of Mexico. "Prior to European settlement and twentieth-century development, this landscape included woodlands of sugarberry, pecan, elms, and live oaks, and open prairies with native grasses. The flora includes tall grass and mid-grass prairies, cord grass marshes, mesquite, and acacia. Rare and near-extinct plants and animals include the slender rush-pea, Attwater's Prairie Chicken, and the ocelot."[13] Current vegetation in the Community is residential and urbanized. There are no identified sensitive areas in the Watershed (as shown in Figure 11.)

Halls Bayou in this portion of its reach has been channelized by the U.S, Army Corp of Engineers. Its banks are steeply pitched and grass covered. (See Figure 12) The Watershed is located on the Central Flyway of the North American Migratory Flyway. Species seen during the spring season include the American Golden Plover, Chimney Swift, Ruby-throated Hummingbird. Purple Martin, Barn Swallow, Robin, Northern Parula and several other species of warblers, Hudsonian Godwit, Canadian Goose, several species of ducks, yellow-billed Cuckoo, and Olive-sided Flycatcher.[14] Egrets are seen on a regular basis along the bayou as are resident songbirds, ravens, and buzzards. A few small alligators, copperheads, water moccasins, coral snakes and bull snakes are also present.

2.3.3 Water Sources

The Watershed lies above the Chicot aquifer. Originally, all water used in the neighborhood came from private wells. Currently, the FWSD provides municipal water service to the Community. The water source is surface water from Lake Houston. A few homes remain on shallow private ground water wells. According to the FWSD, most of these ground water wells are assumed to be contaminated with indicator bacteria (*E. coli*).

[13] Texas Center for Policy Studies and Environmental Defense. 2000. Texas Environmental Profile. Retrieved April 5, 2008.

[14] Texas Parks and Wildlife Department. 2008. Migratory Flyways of North America – Central Flyway. Retrieved May 7, 2008 from http://www.tpwd.state.tx.us/huntwild/wild/birding/migration/flyways/central/.

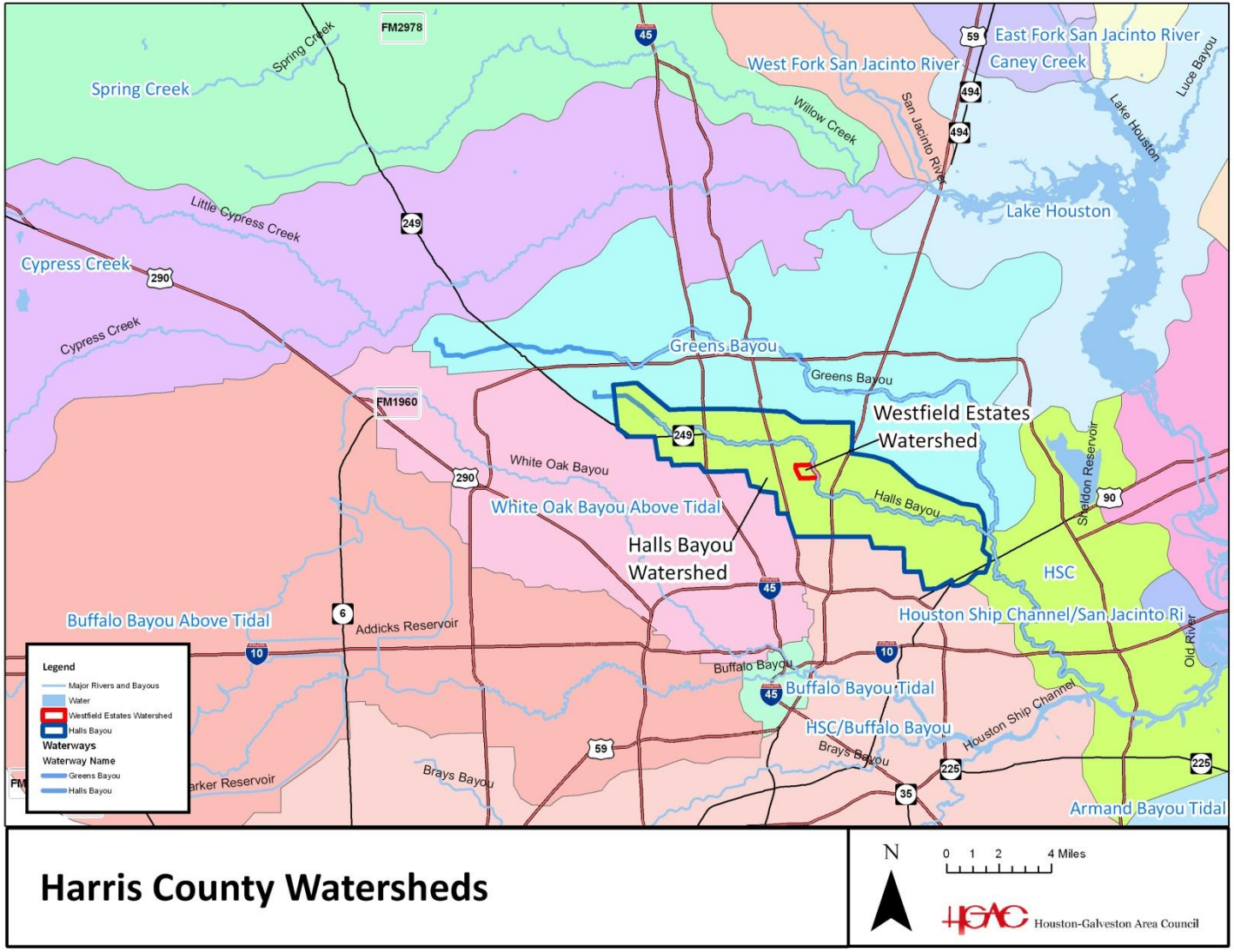

Figure 9: Harris County Watersheds including Westfield Estates Watershed
(Map source: H-GAC, 2009)

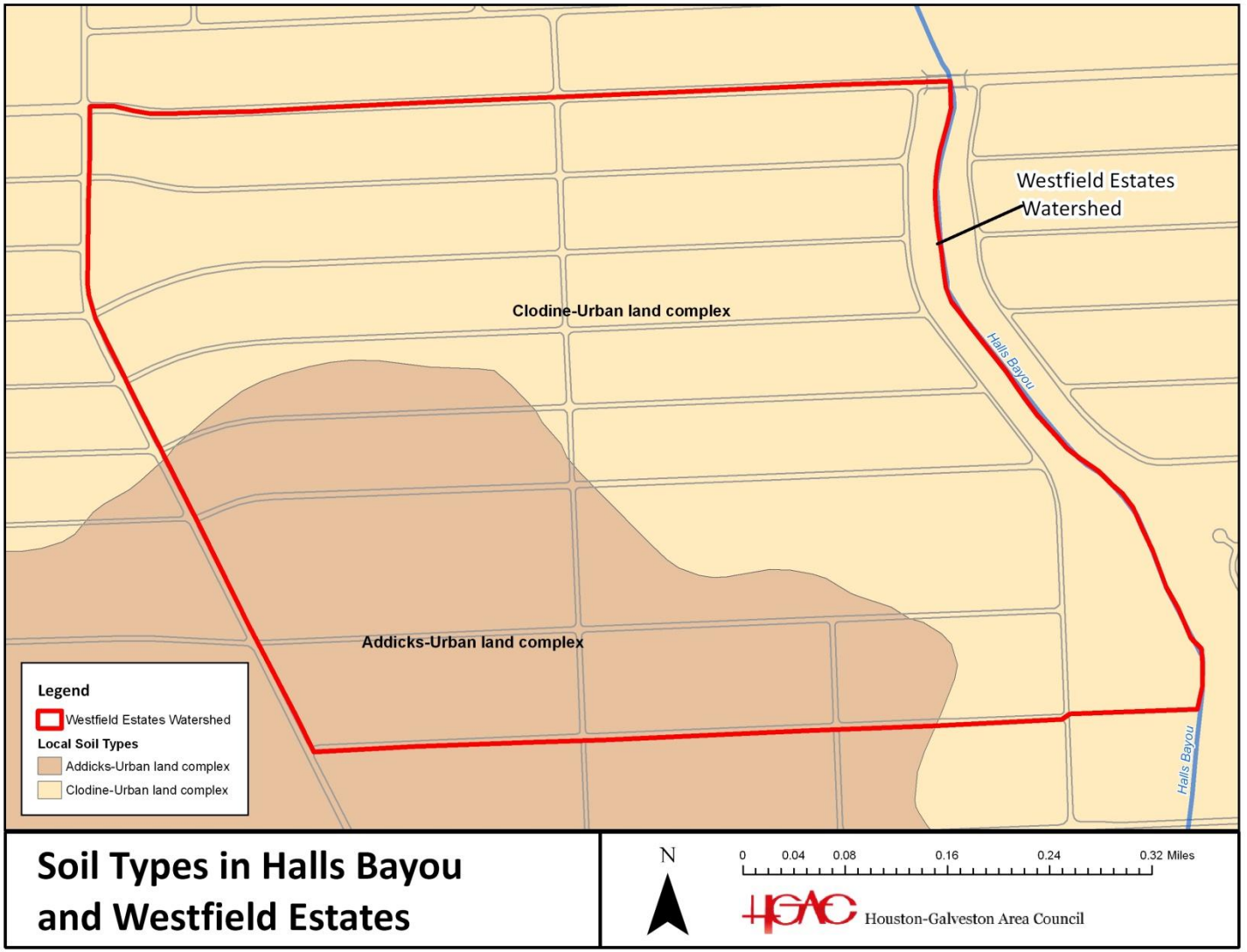

Figure 10: Soil Types in Westfield Estates and Halls Bayou Watersheds
(Map source: H-GAC, 2009)

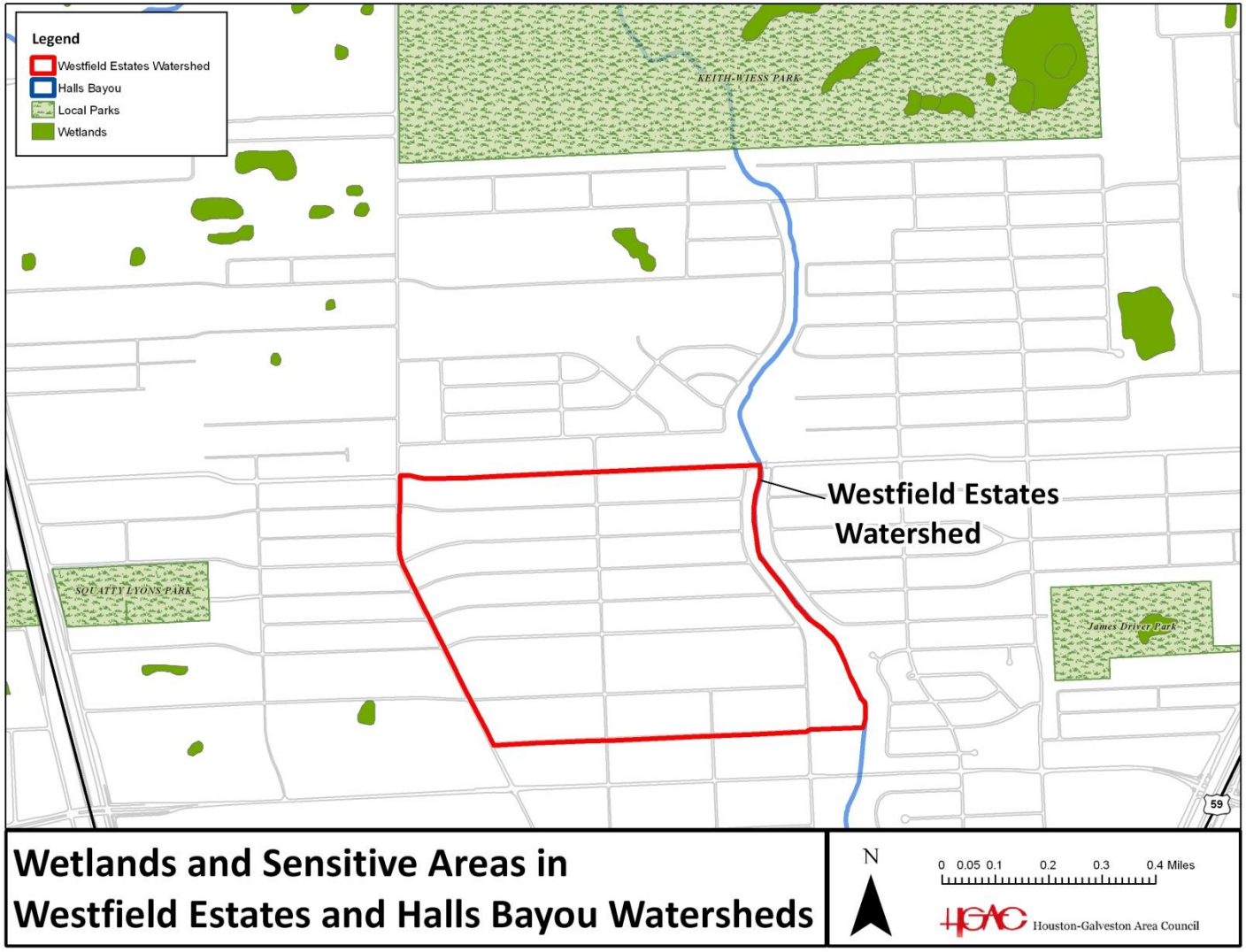

Figure 11: Wetlands and Sensitive Habitat Map – Westfield Estates Watershed
(Source: H-GAC, 2009)

Figure 12: Westfield Estates Watershed Stormwater Outfall into Channelized Halls Bayou
(Photo Source: H-GAC, 2006)

2.3.4 Climate

Westfield Estate's climate, like that of Houston, Texas is warm, sunny and tropical most of the year. The average high temperature is 93 degrees Fahrenheit (F) in summer and 61 degrees F in the winter. Summer temperatures in August and September can range over 100 degrees F for weeks. In the summer, humidity is high and the air feels much warmer than the actual temperature. The average low temperature in summer is 72 degrees F and in winter, 40 degrees F.

Several days of freezing temperatures usually occur every year, most often in January or February. The warmest month of the year is July with an average maximum temperature of 93.60 degrees F, while the coldest month of the year is January with an average low temperature of 45.20 degrees F. The growing season is approximately 300 days a year.[15]

2.3.5 Precipitation and Hydrology

Terrain in the Watershed is virtually flat. Halls Bayou has the lowest conveyance of any bayou in Harris County. Dry weather flow at locations at Westfield Estate outfalls into Halls bayou, upstream two miles, and downstream one mile are almost identical at 0.104 miles per second (MPS).

The annual average precipitation in Houston is 53.34 Inches. Average rainfall at Westfield Estates is slightly less at 46-48 inches annually. (See Figure 13) Rainfall is evenly distributed throughout the year. The wettest month of the year is June with an average rainfall of 6.25 Inches.[16] Rainfall Runoff Curves for the Halls Bayou and Westfield Estates Watersheds are shown in Figure 14 (These numbers represent calculated runoff values based on soil types and land cover, and indicate differences in how precipitation in the Watershed is retained or shed). According to the Weather Research Center in Houston, heavy rains regularly occur in and around the Watershed. The Watershed has received 8 to 10 inches of rainfall within an 8 to 12 hour period in the past, and up to 20 inches within a 24-hour period during Tropical Storm Allison. This amount of rain has caused flooding in the Watershed for many years.

The Watershed area, including Halls Bayou, has a long history of flooding. It was channelized in the 1930s to alleviate flooding, but flooding and erosion continue. Periodic flooding from Halls Bayou adds to potential human health concerns as well as water quality degradation.

Most of the Community is within the Hundred Year Flood Plain (Figure 15). Westfield Estates residents were displaced by several feet of floodwater from Tropical Storm Allison in 2001. Many homeowners are still recovering from the effects of the flood. A few FEMA "blue tarps", the result of wind damage from TS Allison, are still visible. Additional damage occurred as a result of Hurricane Ike.

[15] Cities Graduate Hotline. 2008, Retrieved on July 23, 2008 from http://city.graduateshotline.com/cityprofiles/houston.html.

[16] IDCICE. 2008. Retrieved on July 23, 2008 from http://www.idcide.com/weather/tx/houston.htm.

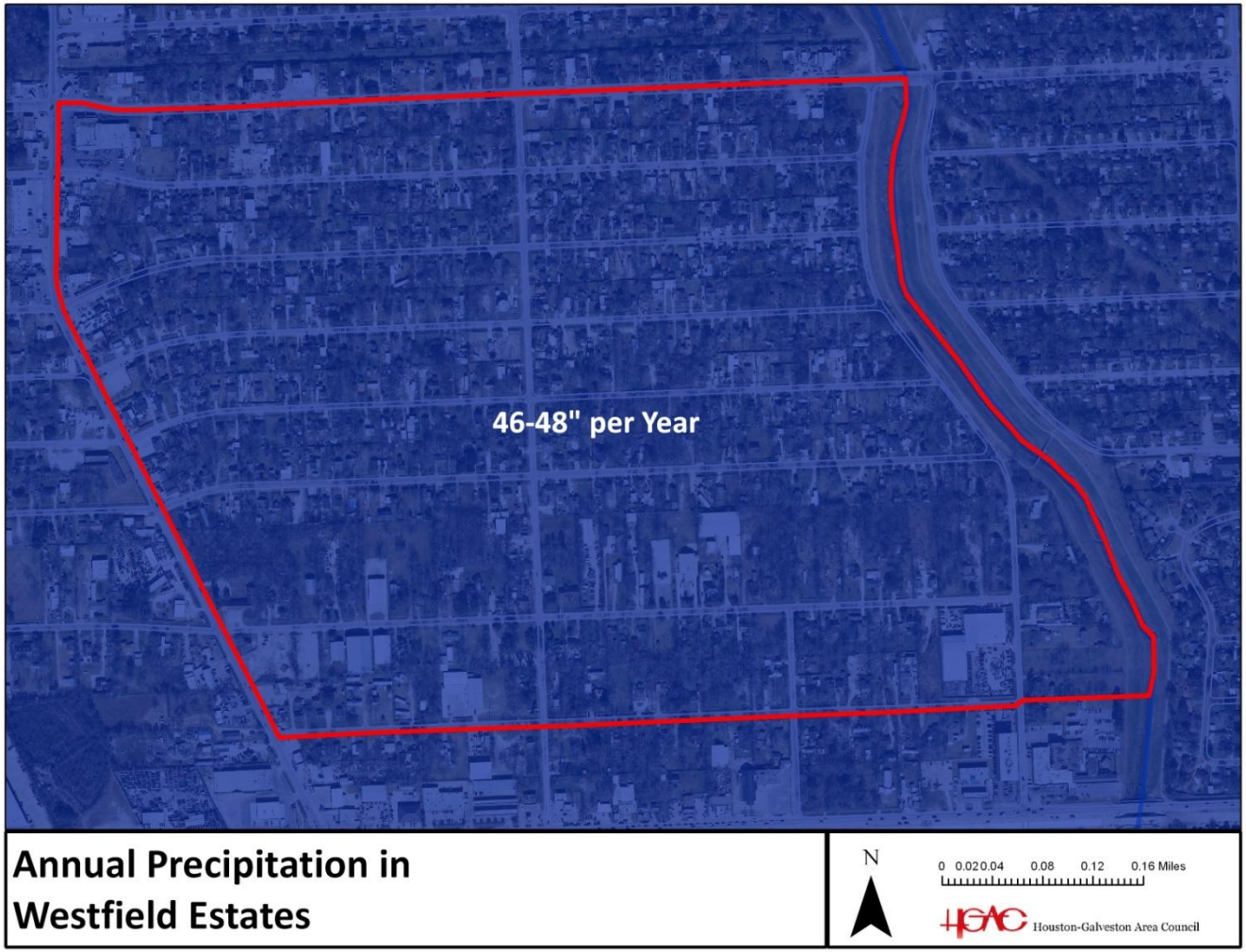

Figure 13: Annual Precipitation for Westfield Estates Watershed
(Map source: H-GAC, 2009)

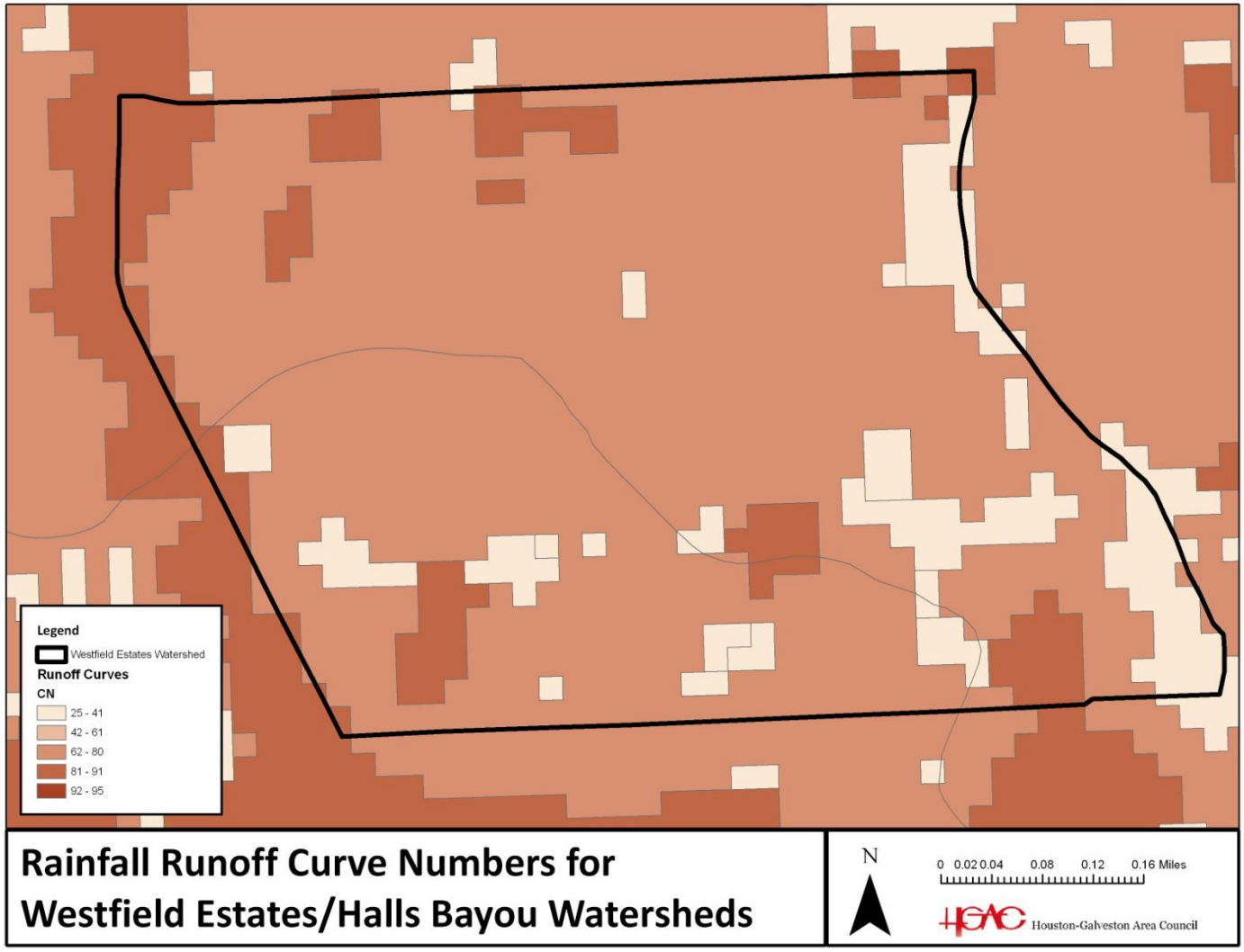

Figure 14: Rainfall Runoff Curve for Westfield Estates Watershed
(Map source: H-GAC, 2009)

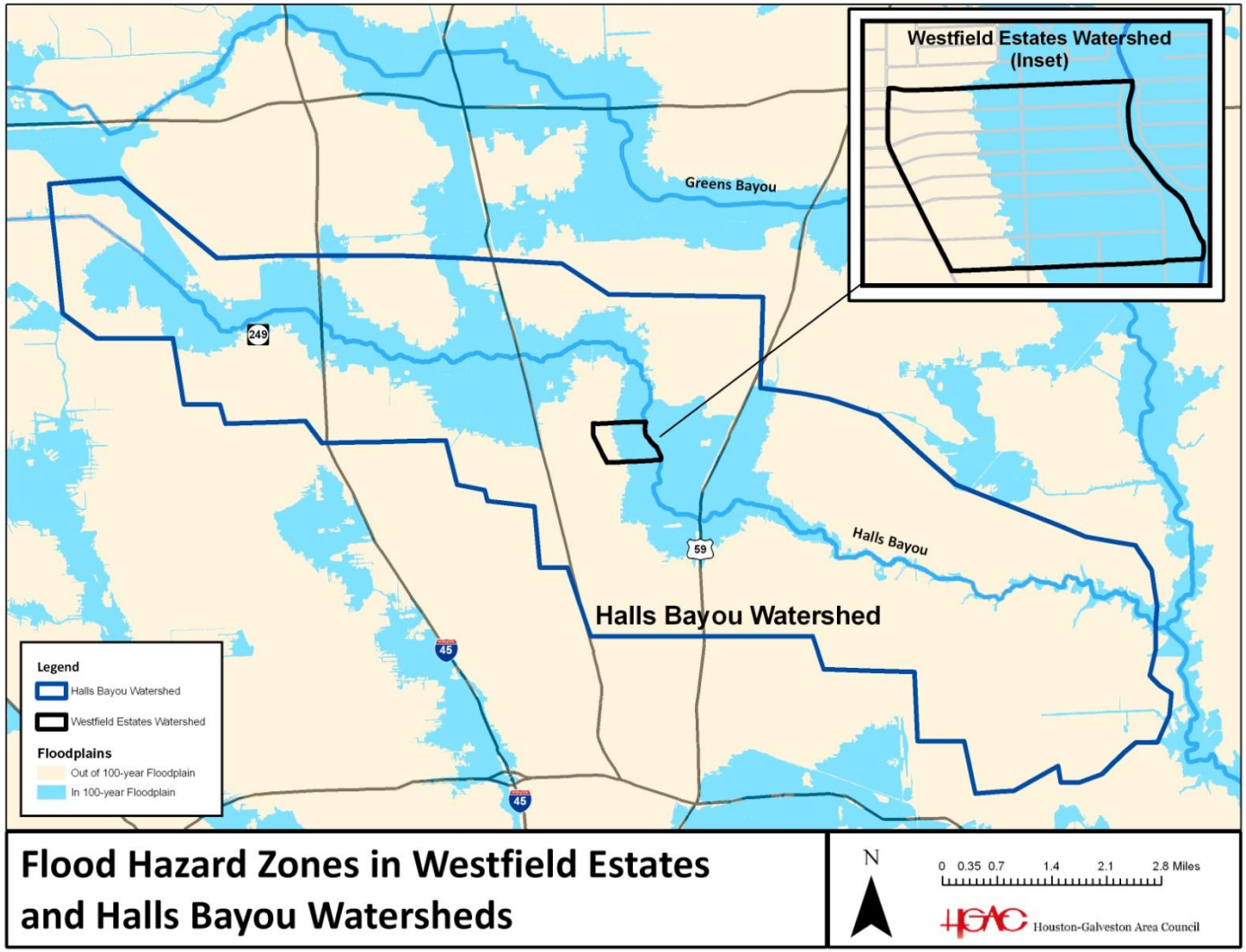

Figure 15: Harris County Flood Plain Map for Halls Bayou
(Map source: H-GAC, 2009)

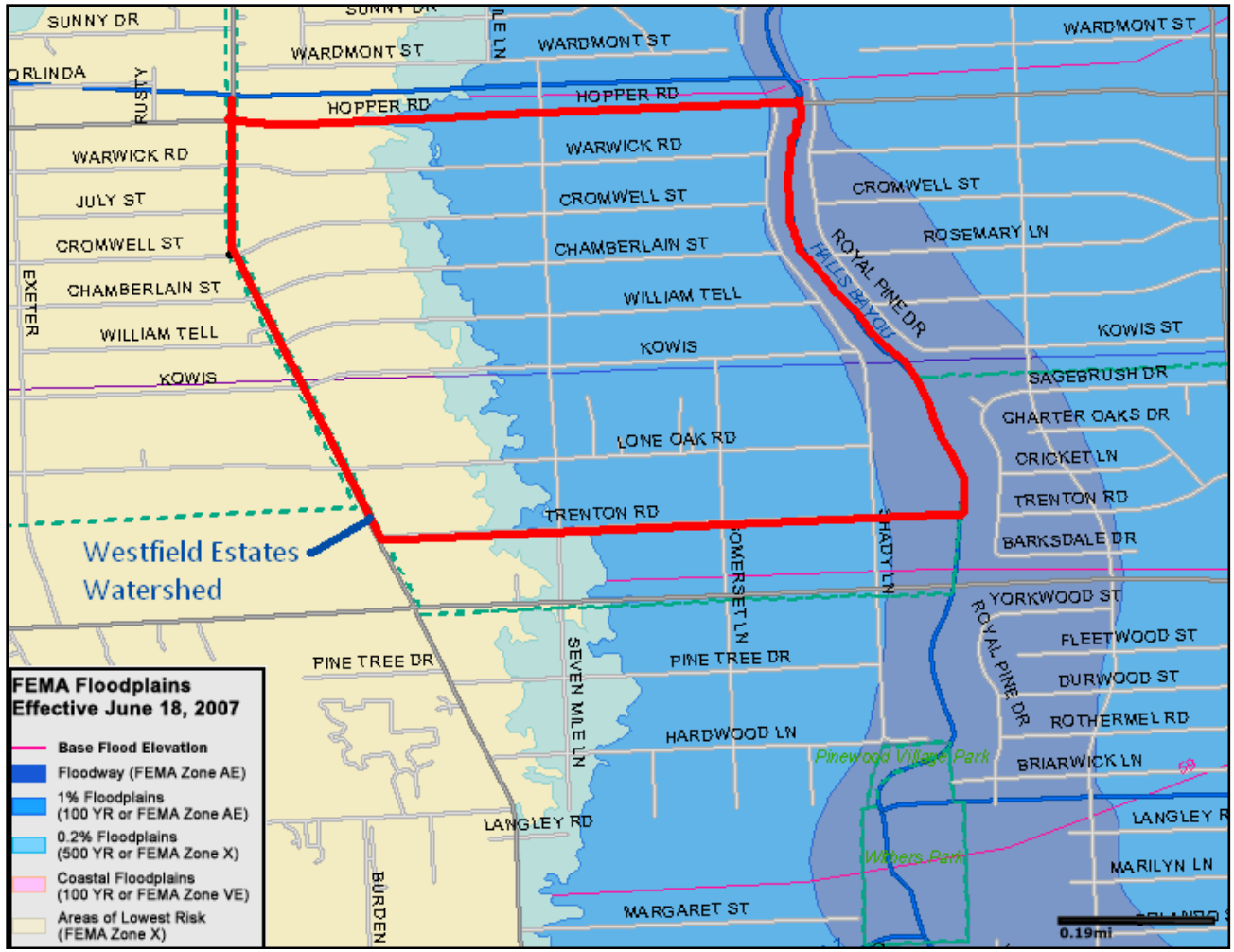

Figure 16: Surface Hydrology of Westfield Estates Watershed[17]

[17] Harris County Flood Control District and Federal Emergency Management Administration. 2007. Tropical Storm Allison Recovery Project (TSARP) Flood Plain Maps Effective June 18, 2007. Retrieved 8 May 2008 from http://maps2.tsarp.org/tsarp/.

2.4 Other Plans in Place in the Westfield Estate Watershed

There are several regional watershed plans and nonpoint source pollution efforts that encompass the Watershed area. These include the Harris County Flood Control District Plan, the Galveston Bay Estuary Program Plan, the Halls Bayou Federal Feasibility Study (Flood Control), the Harris County/Harris County Flood Control District Bacteria Reduction Plan and the TPDES Phase I Stormwater program, under the authority of the Clean Water Act (CWA). The Westfield Estates WPP is a separate document, which may be integrated by these entities into their plans later. A TMDL process has begun for the Houston Metro Area, which includes Westfield Estates. The results of that TMDL process, if applicable, will be incorporated into the WPP.

2.4.1 Harris County Flood Control District

The mission of the Harris County Flood District Watershed Plan (HCFCDP) is to "Provide flood damage reduction projects that work, with appropriate regard for community and natural values," which includes an understanding of the 22 watersheds within its jurisdiction. Greens Bayou, which contains Halls Bayou, is one of these watersheds. The program, called the Watershed Environmental Baseline (W.E.B.), acts to:

- "Identify those segments of streams that maintain high natural habitat values in order to avoid degradation as part of future flood damage reduction measures;
- Distinguish between floodplain tracts that either possess characteristics making them best suited for either regional stormwater detention basins or to leave them alone, preserve them and let them provide areas for floodwater storage; and
- Identify environmentally sensitive areas, areas having other concerns such as contamination or areas that others are working to preserve."

Inventories for each watershed identify natural, cultural, and physical resources deemed necessary to evaluate potential project alternatives. These include wetlands, potential and current site with cultural value, "threatened and endangered species locations and sensitive/unique habitats, hazardous and toxic materials sites, pipelines, oil and gas well locations, stream habitat quality assessment, and FEMA floodplains.[18]

2.4.2. Galveston Bay Estuary Plan

The Galveston Bay Plan (GBP) is a "Comprehensive Conservation and Management Plan (CCMP) for the Galveston Bay ecosystem of 28 estuaries, developed as a part of the National Estuary Program process." Although the Watershed is approximately 80 miles from Galveston Bay, it is still part of the coastal estuary ecosystem.

GBEP helps build consensus among stakeholders in the Galveston Bay ecosystem who become partners in the Plan implementation process. These include private citizens, industry, business, development, academia, and government. Its overall mission is to "protect and restore the health

[18] Harris County Flood Control District. 2008. Watershed Environmental Baseline (W.E.B.) Plan. Retrieved on July 20, 2008 from http://www.hcfcd.org/webprogram.html.

of estuaries while supporting economic and recreational activities." The overall mission of the GBEP is to protect and restore the health of estuaries while supporting economic and recreational activities. Plan implementation includes the following:

- Tracking and monitoring implementation of specific actions by the Plan's partners;
- Coordinating activities of the Plan's partners;
- Identifying and communicating bay improvements to agencies, stakeholders, and the public;
- Redirecting the Plan where improvements lag;
- Conducting public outreach and education to increase awareness of Galveston Bay;
- Advocating conservation of the estuary; and,
- Convening meetings of the Galveston Bay Council, and advisory council for plan implementation.[19]

Goals and implementation strategies of GBEP do not specifically address bacteria water quality issues from OSSFs.

2.4.3 Halls Bayou Federal Feasibility Study

The HCFCD is conducting the Halls Bayou Federal Feasibility Study in an effort to identify a plan that would address flooding in the Watershed and other communities along Halls Bayou. Potential partners include Harris County Precinct 1, HCPCT2, the City of Houston Parks and Recreation Department, the EAMD, Aldine ISD and the U.S. Army Corp of Engineers.

The feasibility study, which began in 2005, currently focuses on gathering information and gaining a better understanding of opportunities within The Halls Bayou Watershed to alleviate flooding. Additionally, HCFCD is conducting environmental assessments and public involvement activities to comply with the standards set forth by the National Environmental Policy Act. The feasibility study is expected to be completed in five years.

The project envisions three stormwater detention basins to help reduce the risk of flooding. The first includes a 100 acre basin within the 500 acre Keith-Weiss Park, which was recently completed. The design provides for the preservation of old forest habitat along the bayou, while creating large ponds and wetlands in the bottom for water quality enhancement and habitat value. Trails and other amenities are planned for around the basin and several thousand trees, shrubs and wetland vegetation will be planted. This basin is approximately 1.5 miles north of the Watershed. The other two detention basins (Brentshire and Halls Park) are south of the Watershed and will not affect flooding there.

The Study Schedule for federally funded flood damage reduction on a major stream is a decades-long process. To meet the requirements and be considered for federal funding support, the District is required to do an extensive and lengthy (seven to five year) study, in cooperation with the U.S. Army Corps of Engineers. HCFCD initially funds the planning, design and construction, but can be reimbursed for at least 50 percent of implementation costs if the proposed project is approved and if funds are appropriated by Congress. The main benefit of this

[19] Galveston Bay Estuary Program. 1994. The Galveston Bay Plan. Retrieved on July 30, 2008 from http://gbic.tamug.edu/theplan.html.

process is that time for implementation can be significantly reduced from 25 years to 10-15 years. Total estimated cost for the project is $125 million (2003 dollars).

2.4.4 Harris County/Harris County Flood Control District Bacteria Reduction Plan

On July 8, 2008, Harris County Commissioners Court adopted a Bacteria Reduction Plan for area waterways to be implemented by both Harris County and HCFCD. The plan establishes steps to be taken over a 5 –year period to reduce bacteria in local waterways and was created with local stakeholder input, including representatives from the environmental, engineering and development communities. Total suspended solids (TSS) and nutrients released into local waterways are also addressed in this plan, as they are believed to be co-pollutants to bacteria. The plan was created to ensure logical progression of programs so no public or private money is wasted on unproven or inconclusive "fixes", while allowing research to progress that will help us understand new ways to reduce bacteria from sources not fully understood currently. The plan addresses the following eight categories of potential pollutant sources:

1. Prioritization of resources based on stream usages,
2. Wastewater treatment plants,
3. Research,
4. Program and plan monitoring,
5. Stormwater pipe/ ditch discharges (excluding sanitary sewer overflows),
6. Sanitary sewer overflows,
7. OSSF's, and
8. Associated programs (including wildlife, a bayou public awareness campaign, etc.).

As stated previously, the Harris County and Harris County Flood Control District Bacteria Reduction Plan is designed to reduce bacteria in our area waterways. It is expected that the Westfield Estates WPP will compliment the Harris County plan and is expected to further reduce bacterial water quality issues in the area.

Figure 17: Greens Bayou/Halls Bayou Flood Control Plan[20]
The Watershed is located between the northernmost and middle detention ponds proposed.

2.4.5 Houston Metro TMDL

A TMDL is like a budget for pollution. The Clean Water Act and the EPA require that all states identify water bodies that do not meet, or are not expected to meet, applicable water quality standards for designated uses. These water bodies are listed and prioritized in order to schedule TMDL development. A TMDL study is a technical analysis that determines maximum loadings of a pollutant of concern that a water body can receive and still meet water quality standards and allocates this allowable loading to point and nonpoint pollutant sources in the Watershed. The Watershed is located in Halls Bayou Watershed, which is part of the Houston Metropolitan Area TMDL.

Stakeholders from the Houston Metropolitan Area, including several stakeholders from the Westfield Estates WPP SAG are working to develop an implementation plan to reduce bacteria in area waterways. The Bacteria Implementation Group (BIG) is the committee responsible for developing the area plan. Implementation practices in this WPP are consistent with those currently under development in the TMDL.

[20]Harris County Flood Control District. 2007. Halls Bayou Watershed. Retrieved 7 May 2008. http://www.hcfcd.org/P_hallsbayou.html.

2.4.6 Texas Pollution Discharge Elimination System Phase I Stormwater

This program addresses sources of storm water runoff that have the greatest potential to negatively impact water quality. It promotes a comprehensive approach to mitigating nonpoint source pollution. The Watershed falls under the jurisdiction of the Harris County Phase I permit.

While there are several general areas of overlap with the aforementioned plans the Westfield Estates WPP is a unique, stand-alone document that does not draw significantly on information from any of the above plans. It specifically targets the Watershed, and is focused solely on meeting its particular needs and engaging its local stakeholders. Priorities for implementing construction and behavioral BMPs have been determined and coordinated with a diverse group of stakeholders many of whom have contributed financial support to the Westfield Estates WPP. While this WPP is local in scope, it still allows for regional coordination. The Westfield Estates WPP's Quality Assurance Project Plan (QAPP) will be reviewed by TMDL staff prior to implementation. A number of Westfield Estates WPP stakeholders sit on the Houston Region's TMDL Bacterial Implementation Group committee and sub-committees, which allows for a free flow of information about the WPP.

3.0 WATER QUALITY DATA

In order to protect precious water resources, water quality standards have been developed and implemented on the federal, state and local levels. "Water quality standards are comprised of three elements: designated uses, numeric and narrative criteria, and anti-degradation policies and procedures. Water quality standards set the goals, pollution limits, and protection requirements for each water body." Standards applicable in the Westfield Estates WPP include the Ambient Water Quality Criteria for Bacteria – 1986 (Criterion)[21] and the National Pollution Discharge Elimination System (NPDES), which has two components: point/nonpoint source pollution regulation and pollution management.

To assess water quality, various types of monitoring, both regular ambient and special types, occur. These efforts include monitoring bacteria levels in the Watershed, using *E. coli* as a surrogate for human pathogens. Bacteria levels in excess of the State Criteria for contract recreation are the leading water quality concern in the Watershed.

The following subsections are descriptions of the standards applicable to this WPP and the data sources accumulated and reviewed in its production.

3.1 Water Quality Standards

3.1.1 Ambient Water Quality Criteria

The Ambient Water Quality Criteria establishes a criterion for the upper limits for densities of indicator bacteria (*E. coli*) in waters used for primary contract recreation. The Criterion's basis is epidemiological studies conducted in the 1970s and 1980s.[22],[23],[24] The Criterion is and has been the subject of extensive review and criticism because of flaws in study design, data collection, and analysis, most recently in U.S. Environmental Protection Agency's own 2007 Expert Scientific Workshop proceedings.

The TCEQ, in accordance with the Criterion, has established a Standard for levels of *E. coli* it considers to provide acceptable risks to the human population (Texas Surface Water Quality Standards, 30 TAC Chapter 307; TCEQ RG-194, January 2003).[25] The Standard applicable to

[21] Environmental Protection Agency. 1986. Ambient Water Quality Criteria for Bacteria – 1986. U.S. Environmental Protection Agency, EPA-440/5-84-002. Cincinnati, OH.

[22] Cabelli V, Dufours A, Levin M, Habemann P. 1976. The impact of pollution on marine bathing beaches: an epidemiological study. In: Middle Atlantic Continental Shelf and the New York Bigh: Proceedings of the Symposium, American Society of Limnology and Oceanographers, 3-5 November 1975. New York New York, Lawrence KS: American Society of Limnology and Oceanography:424-432.

[23] Cabelli VJ, Dufour AP, Levin MA, McCabe LJ, Habermann PW. 1978. Relationship of microbial indicators to health effects of marine bathing beaches. Am. J. Public Health 69(7):690-696.

[24] Cabelli, VJ, Dufour AP, McCabe LJ, Levin MA. 1982. Swimming associated gastroenteritis and water quality. Am. J. Epidemiol. 115(4)606-616.

[25] USGS. 2008. National Water Information System: Web Interface. USGS 08076500 Halls Bayou at Houston, TX. Retrieved on May 7, 2008 from http://waterdata.usgs.gov/nwis/measurements/?site_no=08076500&agency_cd=USGS .

the Watershed is 126 MPN/100 ml of *E. coli* in water for the geometric mean or 394 MPN/ 100 mL for a single grab sample.

In applying the Criterion to a water body, it is important to define and identify the type of contact recreation that occurs. Use relates directly to exposure and by corollary, to dose response. Two categories are used in Texas, primary contact recreation use and non-contact recreation use. Some states also have another category for secondary contact recreation.

The definition of ***primary contact recreation*** is "a significant risk of ingestion of water or full body immersion; examples include wading by children, swimming, water skiing, diving, surfing, scuba diving, and subsistence fishing." The nature of the activities needs to be clearly defined. For example, ingestion in fresh water is assumed greater than salt water. Children are assumed to have the greatest exposure in any activity.[26]

TCEQ and EPA state a risk to human health exists if bacteria levels are above 126 MPN/100 ml of *E. coli* in water for the geometric mean or 394 MPN/ 100 mL for a single grab sample of freshwater. This is estimated at approximately eight illnesses per 1000 swimmers.

Non-contact recreation (NCR) is incidental contact where the probability of ingesting appreciable quantities of water is minimal. It also includes any type of contact recreation considered unsafe for reasons unrelated to water quality or recreation prohibited in water bodies for safety reasons (i.e. steep bayou banks). Examples include fishing, recreational boating, biking, running, walking, and picnicking as well as limited body contact incidental to shoreline activity.

The non-contact recreation risk level is five times the primary contact recreation geometric mean (630 MPN/per 100 ml), a risk level between 14 - 15 illnesses per 1000 swimmers.

Other states have a category for "incidental contact where the probability of ingesting appreciable quantities of water is minimal." This is called ***secondary contact recreation***. Examples include fishing, commercial, and recreational boating, canoeing, wading by adults, playing in the sand by the water, and limited body contact associated to shoreline activity. Secondary contact assumes parts of the body, primarily the hands, comes in direct contact with the water body, but inhalation might also occur through splashing, waves, and wind.

Additional contact may occur through handling paddles, fishing tackle, fish, canoes, or kayaks. In the case of children, it is assumed that fishing leads to primary contact.

The risk level for secondary contact recreation is the same as for non-contact recreation: 14-15 illnesses per 1000 swimmers, based on a geometric mean that is 5 times the primary geometric mean (630 colonies of *E. coli*). This designation is proposed for assignment only where a Use Attainability Analysis (UAA) has been conducted consistent with 40 CFR 131.10 that further demonstrates there is no reasonable potential for primary contact recreation uses to occur.

[26] Alexander LM, Haven A, Tennant A, Morris R. 1992. Symptomatology of children in contact with seawater contaminated with sewage. Journal of Epidemiology and Community Health. 46:340-3444.

The risk of a person becoming ill following contact recreation is a function of the amount of pathogens in the ingested water and the amount of water ingested. Determining the exact amount of pathogen-containing water ingested or inhaled is difficult though necessary to determine appropriate risk to human health from primary or secondary contact.

The TCEQ also uses the additional criteria for the Clean Rivers Program (CRP), as described in Table 4:

Table 4: Summary of Applicable Ambient Water Quality Criteria

Criteria Type	Standard
Primary Contact Recreation	Bacteria (*E. coli*), 126 MPN/100 mL (geometric mean)/ 395 MPN/100mL (single grab)
Non-Contact Recreation	Bacteria, 630 MPN/100 mL (geometric mean)
State of Texas Clean Rivers Program	Temperature (°C): 33 Dissolved Oxygen (24-Hr Average) (mg/L): 3.0 Dissolved Oxygen (Absolute Minima) (mg/L): 2.0 pH (standard units): 6.5 – 9.0 Chloride (mg/L as Cl): 150 Sulfate (mg/L as SO4): 150 Total Dissolved Solids (mg/L): 1,000 Bacteria (*E. coli*) for Freshwater 126 MPN/100 mL (geometric mean) Bacteria (*E. coli*) 394 MPN/100 mL (grab sample) Ammonia (mg/L): 0.33 Nitrite + Nitrate (mg/L): 1.95 Orthophosphate Phosphorus (mg/L): 0.37 Total Phosphorus (mg/L): 0.69 Chlorophyll-a (µg/L) 14.1

Nutrient screening criteria is currently being used in an attempt to identify future water quality concerns. However, no current water quality standards exist in Texas for these nutrients.

3.1.2 National Pollution Discharge Elimination Program

The NPDES regulates discharges of pollutants from point sources to waters of the United States under Section 402 of the Clean Water Act. Discharges are illegal unless authorized by an NPDES permit.[27],[28]

[27] Environmental Protection Agency. 2008. National Pollution Discharge Elimination System (NPDES). Retrieved on July 20, 2008 from http://cfpub.epa.gov/npdes/home.cfm?program_id=45.

[28] Environmental Protection Agency. 2008. National Pollution Discharge Elimination System (NPDES) Stormwater.
Retrieved on July 30, 2008 from http://cfpub.epa.gov/npdes/home.cfm?program_id=6.

A point source is any "discernible, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock concentrated animal feeding operation (CAFO), landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged. This term does not include return flows from irrigated agriculture or agricultural stormwater runoff." The NPDES-Point Source regulation governs municipal, private, and industrial sources. There are no point sources in the Watershed.

The NPDES-Stormwater regulation addresses stormwater pollution originating from construction, multi-sector (industry), and municipal separate stormwater sewer systems (MS4). Stormwater discharges are "generated by runoff from land and impervious areas such as paved streets, parking lots, and building rooftops during rainfall and snow events that often contain pollutants in quantities that could adversely affect water quality.

Most stormwater discharges are considered point sources requiring regulation by an NPDES permit. The primary method to control stormwater discharges is through the use of BMPs.[29] Stormwater in Westfield Estates is collected in a series of shallow ditches, which flow directly into Halls Bayou via a series of 4 conduits under Shady Lane.

3.2 Available Monitoring/Resource Data – Westfield Estates

The first phase of this WPP was completed in 2000 by H-GAC. Entitled ***Failing Septic System Initiative I[30] (Phase I)***, it was a systematic water quality monitoring project, which collected data in Westfield Estates and at stormwater conduits flowing to Halls Bayou.

3.2.1 Site Selection and Data Collection

Water quality monitoring and field reconnaissance play critical roles in determining and identifying bacterial loading "hotspots," developing an understanding of baseline water quality, examining watershed conditions, and identifying sources of human and nonhuman sources of bacterial contamination.

All of these factors are necessary to develop a sound WPP. Sampling and monitoring were divided into dry and wet weather events with three distinct efforts: field reconnaissance, water quality monitoring for bacterial contamination, and sample collection for the reference library.

H-GAC conducted field reconnaissance prior to bacterial water quality monitoring data to increase understanding of bacterial nonpoint source pollution in Watershed. Field reconnaissance included walking the Watershed, photographing, and recording observations of potential malfunctioning OSSFs or other sources contributing to bacterial or other nonpoint source pollution.

[29] IBID.
[30] H-GAC 2006.

These observations led to monitoring water quality in areas of interest both within the Watershed and also outside in Halls Bayou and the FWSD plant immediately upstream of the Watershed outfalls into Halls Bayou. Results were used to guide the choice of monitoring sites and the Phase II project proposal. Methods and additional information regarding the field reconnaissance effort are available in Section 4.4.2 and in the Phase I study report at: http://videos.h-gac.com/ce/water_resources/ss-ossf_failing_septic_system_initiative_westfield_estates.pdf

H-GAC compiled and reviewed a suite of geographic datasets including high-resolution aerial photography, land cover, hydrology, topography, wastewater treatment plant outfalls and service area boundaries, population density, household locations, precipitation, and OSSF violations identified by Harris County. Analyzing the geographic datasets allowed H-GAC to develop a conceptual model of Community watershed dynamics.

Understanding of "watershed" dynamics and bacterial contamination were enhanced substantially using Geographical Information System (GIS) analysis. GIS imagery went beyond simply mapping the area. High-resolution aerial photography was used to assess Community land use, identify outfalls from wastewater treatment plants, locate OSSF violations, and determine the density of OSSFs. GIS and geospatial analysis were keys to the success of this project.

Local knowledge was critical to the development of an understanding of historical and current activities within the Watershed, identifying data gaps, refining the above-referenced conceptual model, and prioritizing field reconnaissance efforts and planning agency interviews. H-GAC gathered local knowledge using a variety of techniques, explained further in later sections of this WPP and in Section 3.5 of the aforementioned Phase I report.

3.2.2 Water Quality Monitoring—Bacteria

The occurrence of *E. coli*, Enterococcus, Fecal coliform and Fecal Streptococcus bacteria are associated with human sanitary waste, including that generated by malfunctioning OSSFs. They are also connected to fecal bacterial contamination from nonhuman sources. Data were collected from approximately twenty sites in Westfield Estates, plus duplicates, which met sampling criteria, as well as five outfall locations in adjacent Halls Bayou, and one at the WWTP. Initial criteria for selection of sampling locations in Westfield Estates included (1) standing water present during dry weather thought to be related to OSSF malfunction, (2) presence of "black water," and (3) sanitary sewage odor.

Both dry and wet weather monitoring for bacteria was conducted. Monitoring focused on Westfield Estates because of the numerous violations in the Watershed and because of drainage flow.

H-GAC established a series of monitoring sites after field reconnaissance of Westfield Estates. Sites selected were those determined most likely to be contaminated by absent or malfunctioning OSSFs. Additional considerations were geographic distribution, availability of safe and continued access, and land use patterns. Year-round standing water locations provided by

HCPCT2 are shown in Figure 18. Actual sampling locations were chosen after field reconnaissance (Figure 19).

For various reasons, such as water availability and/or safety, it was not possible to sample all locations during both wet and dry periods. Field reconnaissance established the presence of possible nonhuman sources of bacterial contamination, including dogs and chickens.

Figure 18: Dry Weather Standing Water Locations in Westfield Estates
(Source: Data -HCPID; Mapping - Houston Galveston Area Council)

Figure 19: Westfield Estates, Halls Bayou, and WWTP Sampling Locations
(Source: Houston-Galveston Area Council)

Westfield Estates—Warwick Street
Five sampling locations were located on Warwick Street. Two were located in the 2100 block, one in the 2300 block, and two in the 2400 block of the street. Water samples were collected from standing water in ditches in front of residences. Ditch water flowed toward the east, from the 2100 block toward the 2400 block, with the terminus of the street's ditch connected to a two foot in diameter conduit under Lazy Lane, which runs along the west bank of the Halls Bayou, leading to an outfall into the Bayou.

Westfield Estates—Cromwell Street
There were five sampling locations on Cromwell Street, one in the 2400 block, two in the 2500 block and one in the 2700 block of the street. Mosquito larvae were evident in most of the ditches.

Westfield Estates—Chamberlain Street
No sites, which met sampling criteria during dry weather events, were available on this street.

Westfield Estates—William Tell Street
Five sampling sites were located on William Tell including one in the 2100 block, one in the 2500 block, two in the 2600 block, and one in the 2700 block.

Westfield Estates—Kowis Street
There were four sampling locations on Kowis. Three were located in the 2500 block and one in the 2700 block.

Sampling Frequency and Parameters
Hygeia Laboratories, Missouri City, Texas collected bacteria water quality samples, fecal source identification reference samples, and performed laboratory analysis in accordance with the project TCEQ-approved QAPP. Specific field techniques, laboratory methods, and other specifications are included in both the Phase I QAPP, which was amended for the Phase II project, which is the current 319(h) grant project under which this WPP is being finalized and implemented.

Monitoring parameters include enumeration of *E. coli*, Enterococcus, Total coliform, and Fecal streptococcus; source identification reference library samples (human, canine, and poultry); and bacterial source identification of individual isolates using Carbon Utilization Profiles (CUP) according to BIOLOG methodology. This methodology is available in the QAPPs for both the Phase I study and the Phase II project. Statistical regression analysis was performed for source identification.

Sampling occurred on four wet weather events (September, November, and December 2006, and January 2007) and one dry weather event (September 2006). Not all locations were sampled during each event with later sampling directed toward areas of highest interest.

Assessing Water Quality Bacterial Contamination
H-GAC examined water samples for the presence of *E. coli*, Total coliform, Fecal streptococcus, Fecal coliform, and Enterococcus. H-GAC assessed water quality conditions by comparing parameter concentrations against State of Texas criteria for contact recreation and determining if waterborne pathogens at sampling sites pose a possible threat to human health. Where values were significantly elevated, H-GAC used the information in the first two stages of risk assessment to aid in the development of the Phase II project.

Data derived from the Phase I and Phase II projects will be used to increase understanding of water quality conditions in accordance with TCEQ's Guidance for Assessing Texas Surface and Finished Drinking Water Quality Data. Findings and results are presented in Section 4.4.2 in this WPP with additional information in the Phase I report available at http://videos.h-gac.com/ce/water_resources/ossf_failing_septic_system_initiative_2007.pdf.

3.2.3 Carbon Utilization Profiles (CUP)

Carbon Utilization Profiles examine the phenotypic bacterium characteristics of catabolism. The BIOLOG method of CUP uses isolates of Enterococcus cultured from the water samples, which are compared to local host-specific isolates. Host specific isolates were obtained from feces of humans and two of the predominant pets in the area, chickens and dogs.

Discriminant analyses of sample isolates compared to host libraries determined the potential source of fecal contamination. Statistical analysis was conducted to predict likelihood of human or nonhuman origin of bacterial species. The method is automated, inexpensive, and allows for a flexible database for identification of bacteria from different sources.

The statistical program Statistical Package for Social Sciences (SPSS) version 15.0 was used to perform discriminate analysis of metabolic traits for three libraries of Enterococcus species, humans, dogs, and chickens. Comparisons were made to derive key metabolic traits from known sources that are likely predictors of group inclusion. After patterns were established, Enterococcus of unknown origin was compared with reference libraries from local sources to determine the likely source of origin.

Water quality data, stakeholder discussions, and field reconnaissance indicate that potential sources of bacteria loading can be divided into four basic types, natural, agricultural, residential, and urban. Examples of these sources include migratory birds, wildlife, chickens (cooped and free ranging), goats grazing, malfunctioning OSSFs, and emergency bypasses from municipal wastewater treatment plants. The potential for all of these exist in the Watershed.

This bacterial source tracking (BST) effort is further complicated by *E. coli* subspecies composition variability, geographic location, collection time, rainfall and habitat. In the case of BST methods, a commensurately large host origin database will be required to encompass these compositional changes for greater reliability. In light of these considerations, the Phase I utilized isolates collected at multiple locations under variable sampling conditions in the Community coupled with rigorous statistical analysis.

Thus, the Phase I results cover 25 locations and 4 different sampling events. Bacterial sources of contamination are indicative of the Community as a whole rather than a single location. The Phase reference library was composed of isolates collected within the Watershed.

While the contribution of bacterial contamination from humans in the Failing Septic System Initiative (FSSI) is significant (16%), one cannot overlook the contribution from nonhuman bacterial sources such as dogs (32.5%), chickens (17.5%), and unknown (34%).

These results are based on limited data. While 66% of the sources of bacterial contamination in the Community have been identified, the level of unknown source of bacterial contamination is significant. Characterization of bacterial contamination source risk factors is essential to the development and implementation of a correction strategy, since correcting bacterial contamination from only a single source, e.g. human, will not significantly reduce bacterial contamination in the Community. Additional pre- and post-implementation monitoring will be part of the implementation of this Plan.

3.2.4 Data Management

H-GAC developed a written QAPP to guide data collection and management activities associated with Phase I. The QAPP and Amendment was submitted to the TCEQ, approved, and made available on the H-GAC website www.h-gac.com. A copy of both is included in Appendix A Quality Assurance Program Plan and Amendments following this document. All samples were collected in accordance with the QAPP.

3.3 Water Quality Threats

Bacteria levels in waterways in the Watershed exceed the Criterion for primary contact recreation, as designated by TCEQ. The Watershed outfalls discharge into Halls Bayou, which is impaired for primary contact recreational uses under the Clean Water Act.

Potential contributors to the bacteria water quality issues are nonpoint source in nature rather than point source related. These include malfunctioning OSSFs, personal pets, domestic fowl, wildlife, feral animals, and migratory birds. Sediment deposition and trash accumulation, identified as secondary concerns in this Plan, are not sources, per se, but facilitate the transmission of bacteria from other sources by creating pools of standing water in which residents may encounter the bacteria.

Phase 1 studies indicated 16% of bacteria in the Watershed and Halls Bayou could be identified as coming from human sources, presumably via malfunctioning OSSFs. The studies also showed that 32.5% of bacterial contamination comes from dogs, either feral or family pets. Many residents in the Community raise chickens for food and there is at least one feral flock of chickens as well. Phase 1 showed that approximately 17.5% of the bacterial water quality issues in the Watershed and in the bayou come from this source. No additional testing will be conducted during this phase of the project to determine the source of the remaining 34% of the bacteria contamination. It is assumed that some portion of the unknown 34% samples represent

previously identified sources which will be impacted by the proposed management measures. Given the nature of the watershed, it is likely that the majority of the rest of the unknown samples are attributable to other avian sources, other wildlife, and other transient sources. The stakeholders held that given the priority placed on the currently identified sources, it was unlikely that further effort and funding of source tracking was likely to change the proposed Plan. Additionally, it is unlikely that there are feasible management measures to deal with other potential sources (migratory wildlife, etc), therefore further identification efforts would not result in a benefit for the cost, nor would it change the proposed source priorities or suite of proposed solutions (e.g. if it was found that a large piece of the 34% was based on migratory birds, there are no feasible management measures to deal with this diffuse source. Therefore, it would not impact the proposed management measures and focus of this Plan).

4.0 POLLUTANT CAUSE AND SOURCE ASSESSMENT

Pollutants in a watershed or water body can come from many different sources. Depending on the number and spatial distribution of potential sources, defining the exact source of many pollutants can be very difficult. In a WPP, evaluating the likely sources of contaminants of concern is a first step toward prioritizing these sources/contaminants and then designing and implementing management measures to effectively deal with them. Common water quality pollutants of concern include bacteria, nutrients, heavy metals, toxic and hazardous materials, and other byproducts of natural and anthropogenic processes. Other causes for concern are water conditions like lack of proper levels of dissolved oxygen or other issues like sedimentation, hydrologic issues with the channel, or trash. While these pollutants are examples of a wide range of potential types of contamination in any given watershed, the sources of these pollutants can generally be categorized into two primary categories: point sources or nonpoint sources.

Point sources are discharges coming from a discrete, identifiable outfall or other conveyance. Point sources normally are linked to a required federal or state permit. Examples of point sources include outfalls from domestic wastewater treatment plants and stormwater facilities, as well as industrial dischargers. These facilities are regulated under the TPDES permit program.

Nonpoint sources involve contamination from diffuse areas, and are often related to land use. They are harder to identify because one often cannot tie pollutant or discharge to a specific location. Nonpoint sources in a watershed may include a mix of agricultural land uses (fertilizers, pesticides, waste from feedlots and grazing livestock), atmospheric deposition, wildlife, domestic pets, malfunctioning OSSFs, erosion, and broken underground sewer lines. As point sources are routinely regulated by state and federal agencies, the primary driver of many watershed protection activities is often nonpoint source pollutants.

This section will discuss potential sources of contamination in the Watershed, identified sources, and the data used to characterize and evaluate the pollutants and sources on which the Plan's management measures are based.

4.1 Review of Potential Sources of Contamination

Like many of the urban bayous in the Greater Houston Metropolitan area, bacterial contamination is the primary concern in the Watershed. Water quality data has indicated that bacteria levels greatly exceed the state standards. Because of the nature of the Watershed (consisting of a series of linear drainage ditches in a primarily residential area), data from previous studies, and the known contaminants of concern in other local areas, the focus of this Plan is on bacterial contamination. However, for the sake of emphasizing the WPP holistic approach of evaluating all potential areas of concern in a watershed, other potential sources of contamination were evaluated.

4.1.1 Point Sources

Potential point sources for the Watershed were evaluated based on previous studies in the area, review of state, regional, and federal regulatory databases, and land use data. The potential point

sources in the Watershed primarily include wastewater discharges, stormwater discharges and hazardous waste sources.

Wastewater Discharges
While there are permitted wastewater dischargers in the general vicinity of the Watershed, primarily along Halls Bayou, there are no permitted dischargers within the Watershed's boundary. While the ditches are undoubtedly affected by anthropogenic effluent, the source is not linked to permitted point sources, but to the diffuse contributions of the Community's malfunctioning OSSFs.

Stormwater Discharges
There are no stormwater outfalls identified as discharging into the linear ditches of the Watershed. The input to the ditches is wholly surface drainage flow and potential input from malfunctioning OSSFs.

Hazardous Waste
There are a number of programs that address hazardous waste in communities, including RCRA (the Resource Conservation and Recovery Act), CERCLA (the Comprehensive Environmental Response, Compensation and Liability Act, commonly known as Superfund), Superfund Amendments and Reauthorization Act (SARA), Brownfields, Underground Storage Tanks (UST), and Leaking Underground Storage Tanks (LUST) programs.

According to EPA Envirofacts, there are no sites in or near the Watershed regulated by CERCLA, or by the Superfund Amendments and Reauthorization Act. There are no identified brownfields in the Watershed or the surrounding area and no known underground storage tanks are present. There is one RCRA site located in the Watershed and several others within a mile. (Figure 20)

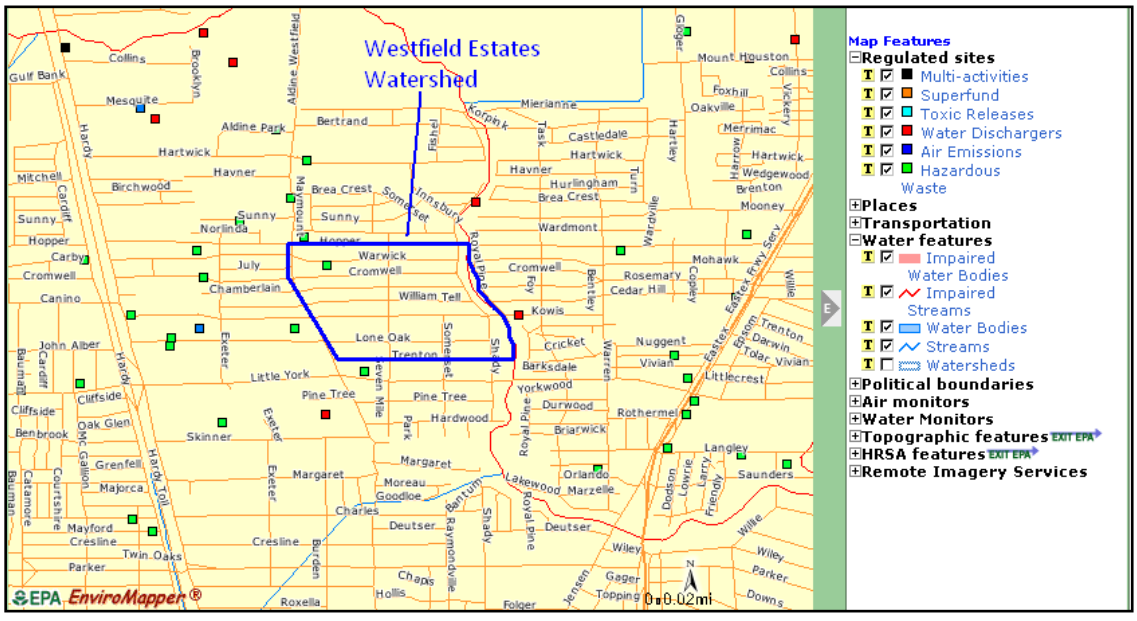

Figure 20: Potential Point Sources of Pollution in Westfield Estates Watershed
(Source: EPA Envirofacts 2009)

All of the RCRA sites are very small companies, most of which operate out of their owner's home (Table 5). RCRA regulates hazardous and non-hazardous wastes, including generation, transportation, treatment, and storage considerations. As there has been no indication of contaminants other than bacteria and nutrients previously been reported in the linear ditches, the potential impact of the one RCRA site in the Watershed is not considered as a primary source of concern under this Plan. It is unlikely that this site or the sites outside the Watershed's boundaries contribute to the bacterial water quality issues. However, as the implementation of the Plan progresses, further evaluation of these sites may be considered if there is concern among the stakeholders or new data to indicate potential water quality impacts.

Given the lack of permitted discharges of effluent or stormwater, and probable lack of impact from hazardous waste sources, point sources do not represent appreciable sources of pollution in the Watershed.

Table 5: Hazardous Waste Sites in Westfield Estates

Business	ID	NAICS Code or Description	Location	Street Location	Status
CUSTOMIZED ANODIZING AND PLATING	TXR000031096	Conditionally exempt small generator	Within Westfield Estates	2157 Cromwell St.	
PROCESSOR AND CHEMICAL SERVICES	TX000820209	Photographic Film, Paper, Plate, and Chemical Manufacturing; Secondary Smelting, Refining, and Alloying of Nonferrous Metal (except Copper and Aluminum)	Outside of Westfield Estates – North	2125 Hopper Rd.	Possible Tank Storage, Active since 1982
WASTE OIL TANK SERVICE	TXD981153067	Petroleum Lubricating Oil and Grease Manufacturing	Outside of Westfield Estates – North	2010 Hartwick St.	Inactive since 1996
GREENFIELD CR INC	TX143806016		Outside of Westfield Estates – North	11722 Aldine-Westfield Rd.	Inactive since 2001
ACTION BUMPER	TXR000031096		Outside of Westfield Estates – North	1919 Lone Oak St.	Inactive since 1999
HOUSTON WELL SCREEN COMPANY	TXR000027425	Oil and Gas Field Machinery and Equipment Manufacturing	Outside of Westfield Estates – North	11939 Aldine-Westfield Rd.	
AAA SEPTIC TANK SERVICE INC	TXD980698252	48411	Outside of Westfield Estates – West	1705 Warwick St.	Inactive since 2003
ULTRACLEAN ELECTRO-POLISH	TXR000057620	Electroplating, Plating, Polishing, Anodizing, and Coloring	Outside of Westfield Estates – West	1814 Sunny Dr.	

4.1.2 Nonpoint Sources

Urban runoff can contain a variety of pollutants, including both bacteria and nutrients. Increased impervious cover (rooftops, roads, and other hard surfaces) causes more surface runoff and less water infiltration into the soil. This greater runoff increases the potential for pollutants from household pets, leaky wastewater pipes, sanitary system overflows, and urban wildlife to reach waterways in a watershed.

Identifying the original source of pollution is extremely difficult, because pollutant runoff from urban areas may potentially come from a combination of several sources. Given these considerations, the potential for significant contaminant contributions exists for all areas of the Watershed. The potential nonpoint sources have been grouped together based on their primary contaminant, although there is a good degree of overlap. The categories evaluated include potential sources of bacteria, potential sources of nutrients, and potential sources of other contaminants. Bacteria and nutrients are given primary attention because they represent established problems in the area, and the majority of sources are related to these pollutants. Based on known and observable sources and testing data, the following sources were evaluated for this WPP.

Potential Sources of Bacteria
There are a wide range of potential sources of bacteria in the Watershed, including pet waste, domestic animal waste, waste from wildlife and human waste from malfunctioning OSSFs.

- Pet Waste: Anecdotal reports, field visits, and the results of the Phase I study and findings of other studies in the local area have indicated that pet waste is a significant potential source of bacteria. BST in the Phase I study indicated that pet waste was a significant percentage of the bacterial load. There are few if any public pet waste disposal stations and the open ditches readily accept bacteria from pet waste left unattended on yard and streets, via runoff.

- Domestic Animal Waste: While large scale domestic animal facilities or operations are not a concern in this urban watershed, some of the Community's residents do have a large number of chickens. Some are caged, but many range freely throughout the neighborhood. BST in the Phase I study showed that bacteria from chickens constitute nearly 18% of the bacteria found in neighborhood drainage ditches. A few pet Pygmy goats are also found in the Watershed.

- Wildlife Waste: In many watersheds across the country, *E. coli* input from wildlife contributes a large portion of the total stream bacteria load. In locations with ideal habitat where populations of riparian animals (raccoon, beaver, and waterfowl) are high, wildlife are major contributors to pollutant loads. In some cases, wildlife populations alone cause violations of bacteria standards. In this urbanized watershed, wildlife should be considered in the background levels of bacteria. There are birds, raccoons, opossum, squirrels, and other wildlife that are common throughout the Houston Area. These

creatures may account for a portion of the unknown sources in the Phase I study. Feral dogs and cats are also prevalent and potentially appreciable sources.

- Malfunctioning OSSFs: Thousands of homes in Houston and unincorporated Harris County still rely on OSSFs to treat their wastewater. The Community is served exclusively by OSSFs, many of which are malfunctioning. If regular and essential maintenance/repairs are not conducted, major OSSF failure can occur as is evident in the Watershed. Lack of OSSF maintenance has been a major issue in some areas and has been acknowledged by homeowners themselves.

  When OSSFs fail, wastewater does not receive adequate treatment. This sewage can be a potent source of bacteria, other anthropogenic pathogens, and nutrients[31]. While inadequate OSSF maintenance is a factor in system failure, other concerns are system design and age. Systems installed before requirements were issued in 1989 are often not as efficient as new systems and are more prone to failure. Degraded materials can lead to a drop in performance and eventual failure. Alteration of the drain field can also dramatically affect OSSF function and may eliminate treatment in worst-case scenarios. Some soils, such as those present in the Watershed also limit system function, as they inhibit leaching and increase the likelihood of overflows. Selection of a system should be determined by soil type, a practice that has not always been followed. Additionally, governing bodies are sometimes hesitant to pursue all remedies available. Justice of the Peace Courts are not always inclined to evict those who fail to maintain their OSSFs from their houses. Fines are generally very modest or not imposed at all. In other areas, as in Westfield Estates, which is under Harris County jurisdiction for OSSF enforcement, resources are adequate for inspection and enforcement, but state rules may have loop holes that affect the Counties ability to address the issue. This contributes to the potential for malfunctioning OSSFs to go undetected and unaddressed. A combination of these factors makes OSSFs a major contributor of both bacteria and nutrients in the Watershed. Those located nearest to waterways are most likely to impact water quality.

  The Phase I study estimated that approximately 40-50% of the OSSFs in the Westfield Watershed may not be functioning properly or OSSFs are non-existent. Based on these findings and the results of studies in nearby areas and physical evidence displayed in field reconnaissance visits, it is clear that malfunctioning OSSFs are a viable potential source of bacteria in the Watershed.

Potential Sources of Nutrients

In addition to bacterial contamination, nutrient sources were examined as a potential source of pollution. Phosphorous and nitrogen from fertilizers, pesticides, and malfunctioning OSSFs can negatively impact water quality. Several sections of Halls Bayou (1006D_01 and 1006D_02), a few miles downstream of the Watershed, were listed on the 2008 Texas State Water Quality Inventory-Basin Assessment Data List for total phosphate, orthophosphate and nitrate. CRP monitoring adjacent to the Watershed shows levels of these possible co-pollutants below action

[31] http://www.epa.gov/waterscience/criteria/nutrient/basic.htm

levels. Potential sources of nutrients in the Watershed include fertilizers and pesticides, human and animal waste, and detergents and other components of OSSF effluent.

- Fertilizers and Pesticides: Use of these compounds is typically less frequent in economically disadvantaged urban communities as compared to more affluent suburban areas (based on lot size, cost considerations, etc.) However, they are potential sources in the Watershed, especially as new development continues to occur in vacant lots.

- Human and Animal wastes: These inputs are known sources of nutrients[32]. As discussed previously, Westfield Estates has high rates of malfunctioning OSSFs and appreciable pet waste inputs that are identified sources of bacterial contamination. These sources also contribute nutrients to the ditches. Given their link to bacterial contamination, these sources are a priority for evaluation in this Plan.

- OSSFs: OSSF effluent contains other nutrient-laden substances like detergents. Therefore, there are several potential sources of nutrient contamination to the ditches.

Potential Sources of Other Contaminants or Issues
In addition to bacteria and nutrients there are other potential contaminants or issues of concern in the Watershed, including deposition of airborne pollutants, sediment and trash.

- **Deposition of Air Pollutants:** Pollution from the air may deposit into water bodies and affect water quality in these systems. Airborne pollution can fall to the ground in raindrops, in dust or simply due to gravity. As the pollution falls, it may end up in streams, lakes, or estuaries and can affect the water quality there. There are five categories of air pollutants with the greatest potential to harm water quality: nitrogen, mercury, other metals, combustion emissions, and pesticides. These pollutants all have the ability to settle into bodies of water and damage ecosystems as well as public health. Both natural and man-made processes can lead to air pollution. Some local water quality issues may stem from atmospheric deposition of dioxin. Dioxin is formed when chlorides are exposed to high temperatures and combustion occurs. Examples include medical waste incineration and the burning of plastics. No combustion source other than automobiles and trucks are found in the Watershed area, although deposition from other sources in the Houston area is a potential contributor.

- **Sediment:** Sediment deposition in the ditches comes from a variety of sources, including the general inputs of runoff from high impervious surface areas, sludge from OSSFs and erosion of the banks. While the sediment levels are not identified as appreciable inputs to Halls Bayou from Westfield, they do impact the efficiency of the linear ditches, which in turns compounds the problem of contamination in those ditches. Many of the ditches have become greatly silted in, causing pooling of contaminated water and potentially representing minor flooding concerns in high flow rain events. The erosion and sediment

[32] As with the reference provided in footnote 30 on the previous page, these nutrient inputs are also generally discussed in the EPA's guidance on National Management Measures to Control Nonpoint Source Pollution from Urban Areas, located at http://www.epa.gov/nps/urbanmm/pdf/urban_guidance.pdf

deposition leads to a reduction in water quality, bank stability issues, pooling, some loss of native aquatic habitats, damage to public utilities (roads, bridges, and dams) and maintenance costs associated with trying to prevent or control erosion sites.

- **Trash:** Field visits to the Watershed and reports from stakeholders have shown large volumes of trash in the linear ditches. There is not a single type of trash that dominates the area, and therefore the composition of potential contaminants deriving form it is variable. While trash is not normally classified as a nonpoint source contaminant, it impedes the flow in the ditches and is a general aesthetic and safety concern for the Community. Therefore, its sources are of potential interest to the Plan. On the internal streets of the Watershed, much of the trash appears to originate from residential sources, while the external streets seem to experience dumping problems, potentially from sources external to the Community.

4.2 Evaluation and Prioritization of Contamination Sources

After cataloging and characterizing the potential sources of contamination in the Watershed, the sources were evaluated based on their relative impact, the relative degree to which they were able to be remediated, and the expressed stakeholder concern. The end result of this evaluation is a prioritization of both contaminants and sources. Much of the data and evaluative process is a result of the studies conducted under the Phase I study. This prioritization is the foundation for the suite of management measures devised to remediate the respective contaminants. Because point sources in the Watershed included only one small RCRA site, they are not considered in this evaluation.

As detailed in the previous section, the sources can be loosely grouped by the nature of the contaminants they produce. These categories are bacteria, nutrients, and other. Of these contaminants, bacteria represent the greatest overall potential human health impact and concern. The primary source of water quality difficulties in the Watershed and adjacent Halls Bayou is bacteria. Phase I of the Westfield Estates WPP included assessment of the water quality issues through bacterial monitoring, analysis source tracking, and linking quantitative data with physical setting, activities, and bacterial nonpoint source pollution in the Watershed.
It also represents the greatest degree of stakeholder concern and is the prime contaminant being addressed in related TMDL processes in the area. Therefore, it is the prioritized contaminant of concern for this Plan. While nutrient pollution is also present, it does not present a direct human health impact. Aquatic life is fairly negligible in the Watershed as the linear ditches are inherently ephemeral and not naturally supportive of a thriving aquatic ecosystem for which low dissolved oxygen would be an issue. The greatest impact of nutrients would be on Halls Bayou, after the stormwater has left the Watershed. Nutrients have less of an acute impact on the Community, and are tied to the same sources (except for limited fertilizer and pesticide use) as bacteria. Remediation of bacteria sources would thus also remediate nutrient sources. The "other" contaminants and issues in the Watershed are secondary concerns that exacerbate the primary issue of bacteria (e.g. pooling caused by sedimentation and/or trash, etc). The data collected in the Watershed (see subsequent sections) supports this prioritization, showing bacteria levels to be well in excess of standard.

Within each category are a number of different sources with differing levels of impact. In order to effectively employ BMPs to remediate the contaminants, the sources were prioritized with each category.

Bacteria
Among the sources of bacteria in the Watershed, OSSFs, pet waste and domestic animal waste all originate from human activity. Wildlife bacterial inputs are less easily controlled as they may be more seasonal and are not typically impacted by physical or behavioral management measures aimed at Watershed residents (e.g. migrating birds). Because OSSFs and pet waste are the most prevalent sources, they are prioritized for remediation. Additionally, because OSSFs are the primary source of human bacteria, because they can be tied to a more discrete source (OSSFs can be inspected), because they generate the greatest stakeholder interest, and because they can be directly, physically remediated (as opposed to behavioral remediation for pet waste practices), they are the primary target for bacteria in this Plan.

Nutrients
The prioritization of nutrient sources closely mirrors that of bacterial sources. Those sources that are directly related to behaviors or conditions that are best able to be remediated are prioritized. OSSF and pet waste inputs are the prioritized sources because they stem from human sources that are also sources of bacteria. Prioritization of these sources allows two contaminants to be addressed by the same management measures.

Other
The various contaminants and issues grouped under this category are secondary to the primary pollutants whether by lack of direct human impact or by lack of relative presence. Deposition of air pollution is not known to be a prominent issue in the Watershed. Because air pollution does not stem solely from the Watershed, because its sources may range over a vast area, and because it was not of primary concern to the stakeholders, air pollution is not a prioritized issue. Trash is a secondary concern as it can serve to block flow in the ditches and presents both aesthetic and hydrologic problems. However, it is variable, not necessarily derived from sources within the Watershed, and has less of a relative impact on human health. Sediment, in terms of erosion and deposition, is an exacerbating factor for the pooling of contaminated water in the ditches. Many of the ditches are partially or completely silted in. Among the issues in the “other” category, sediment is the prioritized condition to be addressed, as is feasible.

4.3 Site Selection

Having developed a catalog of potential sources, reviewed those sources for probable impact on the Watershed, and prioritized them correspondingly, the initial phases of this Plan and previous studies (the FSSI, etc.) combined a series of field investigations and data quantification efforts to further pinpoint the causes of contamination in the Watershed. As stated previously, bacterial contamination was prioritized in this effort.

Review of sewer violations (Figure 21) coupled with locations for persistent standing water in ditches during dry weather (Figure 18) via aerial imagery assisted with prioritizing field reconnaissance and sampling site selection. Harris County provided addresses of actual OSSF permit violations, rather than just complaints.

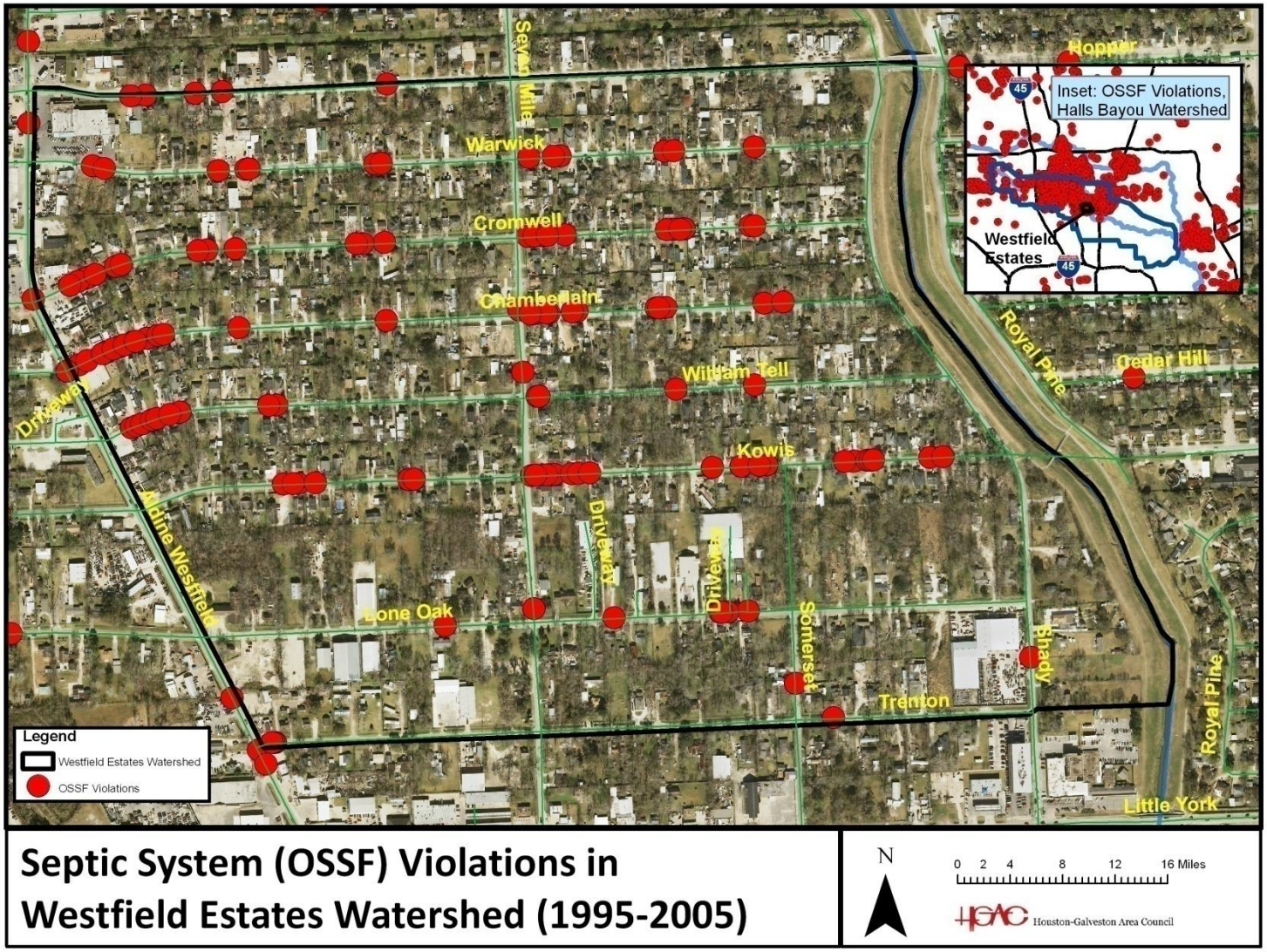

Figure 21: Westfield Estates Watershed OSSF Permit Violations

(Map Source – H-GAC, 2009)

Field reconnaissance was conducted to determine sources of bacterial contamination in Westfield Estates and to identify sampling locations. Sampling locations were chosen based on the results of these and previous efforts, including the located standing water pools. Examples of these sites, which conformed to sampling criteria, are shown in Figures 22 and 23. The sites were chosen so as to consider the ephemeral nature of the waterways, for example, the ditches are dry, except for the standing water pools, in dry weather. Their purpose is to channel water to Halls Bayou rather than retain it indefinitely.

Additional locations are shown in The Phase I report. Varieties of sources for possible bacterial contamination are present in the Watershed. In some locations, presumed OSSF outfalls were clearly visible draining into the ditch. In others, OSSF outfalls were camouflaged behind broken tiles, shrubbery, tree roots, or plants.

Some outfalls were suspected under driveway culverts. Gray water from several homes flowed into ditches as evidenced by larger sized outfall conduit with accompanying soap bubbles and optical brightener "sheen." Ditches also served as repositories for used motor oil and trash. Construction and maintenance of a number of storm water ditches allowed for water to pool.

The flow from the linear ditches combines on the eastern edge of the Watershed to flow into Halls Bayou through a series of outfalls. Halls Bayou (sampling sites on which are shown in Figure 24) receives all the output from the Watershed. The Outfalls from the Watershed into Halls Bayou were initially identified through aerial imagery.

Representative sampling sites were chosen on each of the streets in the Watershed, as discussed in section 3.2.1 of this Plan.

Figure 22: Selected Sampling Locations on Warwick and Cromwell Streets (Sept. 2007)

Figure 23: Selected Monitoring Locations on William Tell and Kowis Streets (Sept. 2007)

Figure 24: Halls Bayou Monitoring Locations (Sept. 2007)

4.4 Field Investigation and Sampling

Sampling and site visits were conducted to quantify and characterize the impact of sources throughout the Watershed.

According to the previous Phase I (FSSI) study, E. *coli* and Enterococcus bacterial contamination existed at all sites examined in the Community and the Bayou, with levels significantly above State criteria for recreational activity. Bacterial sources were identified as human (16%), dog (32.5%), chicken (17.5%), and unknown (34%). The volume of unknown sources of bacterial contamination is significant. Characterization of bacterial contamination source risk factors is essential to the development and implementation of a correction strategy, since correcting bacterial contamination from only a single source, e.g. human, will not significantly reduce bacterial contamination in the Community.

4.4.1 Watershed Field Investigation

Several field investigations were completed, both prior and subsequent to the sampling efforts. The information presented below is a summary of these investigations.

Many dogs and cats roam the neighborhood, with more behind fences. There are many flocks (peeps or broods) of chickens, some feral, others wandering freely between yards and across streets, and some in chicken coops. A few small goats were also seen. Few wild birds, other than crows and sparrows, were prevalent at the time of reconnaissance or sampling, although a variety of birds are common during the migratory seasons. One alligator, approximately two feet long, was seen in Halls Bayou, along with frogs, crows, herons, snakes and an occasional egret.

Several new homes have been constructed on lots whose grade has been raised three to four feet because of flooding. Some new homes had visible aerobic systems. However, at least four new homes on Warwick appeared to be on lots too small to support any OSSF, including some evidence of perennial wet backyards and aerobic spray on neighbor's yards.

Community—Warwick Street

Samples were collected from standing water in ditches in front of five residences on Warwick. Homes are relatively well maintained along most sections of the street and some new construction has occurred recently at the intersection of Seven Mile Road. Many dogs were present on this street. Soap bubbles and detergent from laundry were evident in standing water in some locations. Ditch water flowed toward the east, from the 2100 block toward the 2400 block, with a two foot in diameter conduit under the Lazy Lane leading to an outfall into Halls Bayou. Several ditch locations need maintenance to prevent storm water pooling. (See Figure 18.)

Community—Cromwell Street

There were five sampling locations on Cromwell Street. At least one automobile repair shop is located on this street. One lot contained five trailers, one of which was covered in part with a blue FEMA tarp. Multiple cars were present on various properties. Motor oil had been dumped

into the ditch in several places. The researchers from TAMUG collected samples in the 2500 and 2600 blocks of Cromwell Street for PCR analysis. (See Figure 22.)

Community—Chamberlain Street
No sites on this street met sampling criteria during dry weather events.

Community—William Tell Street
Five sampling sites were located on William Tell. This street has a high concentration of residences needing some form of repair. Several residences have multiple cars in the driveway/front yard. Chickens are present in the street and adjacent yards. Many dogs were also present roaming free or contained within fenced yards. (See Figure 23.)

Community—Kowis Street
There were four sampling locations on Kowis. Some lots contained as many as four trailer homes, with corrugated fencing providing some privacy from the street. At another location, one small lot contained a frame house with two trailer homes tucked behind. Researchers from TAMUG collected samples in the 2500 and 2700 blocks of Kowis Street for PCR analysis (See Figure 23.)

Community—Trenton Road
One sample was collected in the 2700 block of Trenton, adjacent to an automobile salvage yard and across the street from a private residence. Trenton is the southern boundary of the FWSD. An office building with municipal sewage service was close by. Ditch water at this location was relatively clean, although plastic trash bags filled with garbage, an old soccer ball, Styrofoam cups, and plant refuse floated in the water. Collections were made at this location in conjunction with those taken by TAMUG for PCR viral species identification analysis.

Halls Bayou represents the eastern boundary of the study site, with normal channel flow fifteen to twenty feet wide during dry weather. The bayou is channelized with steep, grass-covered banks, except under the Hopper Street Bridge, which is bare ground and gently sloped. Flow is from north to south (Warwick to Kowis). During Tropical Storm Allison, Westfield Estates was covered with several feet of water from the Bayou.

The first monitoring location on Halls Bayou was under the Hopper Street Bridge near the northern boundary of the Watershed on the east bank of the Bayou. TAMUG researchers also sampled at this location. There was little water movement at this bank location and little trash was evident. The second sampling location was on the west side of the bayou, at the Cromwell Street outfall. Water exited the culvert and dropped approximately a foot into the bayou. The third location was at the Chamberlain outfall and the fourth at the William Tell outfall, which was partially below the water level of the bayou at the dry sampling event.

Water was flowing at a rate of several miles per hour in this location. The fifth sampling location was taken under the walkway across Halls Bayou, approximately 100 feet south of the Kowis Street outfall. Water at this location was moving very slowly. TAMUG also sampled at this location. The Kowis Street outfall into Halls Bayou is partially crushed, restricting outflow into the bayou. Examples of site views of Halls Bayou are shown in Figure 24.

FWSD Outfall
The sixth and final location on Halls Bayou is the FWSD wastewater treatment plant outfall (WQ0010236001, TX0021253), located approximately a quarter mile north of the Hopper Street bridge. Maximum permitted daily flow is 0.450 Million Gallons per Day (MGD), well below the average plant size for the region (0.75 MGD). Average flow in 2006 was 0.239 MGD or 53% of its capacity. The WWTP has exceeded permitted flow in several cases in recent history, three in 2004 (February, June, and May) and one in February 2005. Flow increases significantly during periods of rain, indicating a possible Westfield Estates WPP with inflow from storm sewers or leaking manhole covers.

H-GAC analyzed bacterial data to provide information on the magnitude of bacterial contamination in the Community and Halls Bayou and to characterize the source of the contamination, either human or nonhuman. Determination of the connection between potential human illness and the presence of waterborne pathogens would be possible after completion of a future epidemiological study. This information is useful in the development of outreach strategy targeted towards homeowners, elected officials, and developers.

4.4.2 Watershed Sampling Data
Fecal coliform, *E. coli*, and Enterococcus bacteria are "indicator" organisms generally measured to assess microbiological water quality. Presence of these organisms is a predictor of waterborne pathogens, bacteria, viruses, and parasites, which cause human illness and water quality degradation.

Infection rates from waterborne pathogens are around 5% in the US, but approach 100% in areas with poor hygiene and contaminated water supplies. Twenty locations were selected in Westfield Estates and six along Halls Bayou. Multiple grab samples were collected. Samples with designations “A”, “B”, etc. indicate grab samples taken from multiple sites in the same block of a given street.

Sampling events covered different weather conditions and temperatures (See Table 6). The September 26, 2006 sampling event (D) occurred during dry weather, with no rain for an excess of 7 days and temperature around 85° F. The November 28 event (W1) was preceded immediately by 1/2 inch of rain two hours prior (72°F) with the December 11 event (W2) preceded by 1/2 inch or rain an hour before sampling (50° F). The January 30 sampling date (W3) was also followed an inch of rain in the Community (45° F).

E. coli quantitative results are shown in Table 6. A summary of analysis for test bacteria (*E. coli*, Total coliform, Fecal streptococcus, Fecal coliform, and Enterococcus) is found in the Phase I Report. Sampling dates for Table 6 are as follows:

D = Dry weather, September 26, 2006
W1 = Wet weather, November 28, 2006
W2 = Wet weather, December 11, 2006
W3 = Wet weather, January 30, 2007
LS = Lab Split FS = Field Splits

Table 6: Bacterial Quantitative Assessment of *E. coli* in Westfield Estates

Address (Block)	Weather	*E. coli* (MPN/dL)
2400 Warwick A	D W1	6600 2000
2400 Warwick B	D W1	19900 1100
2300 Warwick	D (FS) W1	>242000/>242000 >242000
2100 Warwick A	D W1 (LS)	1500 240000/>242000
2100 Warwick B	D (LS) W1 (FS)	15300/ 12000 112000/173300
2400 Cromwell	D W1 (LS)	1400 68700/77000
2500 Cromwell A	D (FS) W1	2800 / 1500 29900
2500 Cromwell B	D W1	800 36500
2500 Cromwell C	D W1	15500 36500
2600 Cromwell A	D (LS) W1 W3 (LS)	13300/12100 64900 5100 / 6200
2700 Kowis	D W1(FS) W3(FS)	242000 43500 / 41100 4500 / 4000
2500 Kowis Puddle	D W1	16100 36500
2500 Kowis A	D W1	120300 >242000
2500 Kowis B	D W1	>242000 >242000
2700 Trenton	D W1 (FS)	700 61300 / 64900
2700 William Tell A	D W1	7100 155300
2700 William Tell B	D W1	>242000 >242000
2600 William Tell A	D W1	45700 141400
2600 William Tell B	D W1	21400 155300
2100 William Tell	D W1 (LS)	242000 >242000 / >242000

A detailed analysis of the effects of season, weather, dry or rain event, ambient air temperature, ambient water temperature and other related factors are beyond the scope of the Phase I report, which was preliminary in nature. Conclusive monitoring results wait the pre-construction monitoring in the Phase II project.

However, data (Table 6) shows that levels of bacteria in ditch water in the Community and Halls Bayou vary considerably depending on sampling date, weather, ambient water temperature, and ambient temperature conditions. Ambient ditch water temperature varied from one to 5 degrees, depending on sampling location event date. Additional information is available on Field Data Sheets, which are available upon request.

E. coli Levels—Westfield Estates
Data shows the presence of *E. coli* above TCEQ criteria for contact recreation (394 MPN/100ml grab sample) at all twenty sampling locations (Table 6). Exceedences ranged from six to 600 fold above the standard and varied by location, sampling date, weather conditions (wet or dry) and temperature. Approximately 50% of the sights exceeded 100,000 MPN/100ml.

E. coli Levels—Halls Bayou
Data shows the presence of *E. coli* above state criteria at all *E. coli* levels in the Bayou were much lower than those in Westfield Estates. Of the 13 samples examined on four different sampling events, three exceeded 100,000 MPN/100ml.

E. coli levels at the site under the Hopper Street bridge, upstream of the Watershed were higher than those downstream (Foot bridge south of Kowis Street outfall), with one exception, the sampling event on December 11 (W2). Although significant levels of bacterial contamination from the Watershed entered the Bayou after rain events, levels decreased to upstream bacterial levels by the time effluent reached the footbridge.

E. coli Levels—FWSD Outfall
Bacterial analysis showed virtually no bacteria at the outfall on two occasions, both wet weather conditions. Thus, the WWTP is not thought to have contributed significantly to the bacteria levels in Halls Bayou on these sampling occasions.

Dilution quickly reduces bacterial concentration. This finding is supported by ambient water sampling at a site approximately 1 mile downstream of the Community. In 2006, levels of *E. coli* for nine sampling events ranged from zero to 1000, with a median (324 MPN/100ml) below the State standard for contact recreation. Only one third of the events exceeded State criteria for contact recreation. The highest *E. coli* levels (1000 MPN/100 ml) were reported within 2 days of a rain event. Section 3.1.3 Ambient Water Quality - Halls Bayou, contains additional information.

4.4.3 Bacterial Source Determination

The most common bacteria indicators from feces of warm-blooded animals are Fecal coliform and Fecal streptococcus (i.e. Enterococcus). Fecal contaminations from human and nonhuman origins pose a possible health risk to humans.

Fecal coliform includes *Citrobacter freundii*, *Enterobacter aerogenes*, *Escherichia coli*, and *Klebsiella pneumoniae*. Fecal streptococci include *Enterococcus avium* (bird), *Enterococcus faecalis*, *Enterococcus faecium*, *Enterococcus gallinarum*, *Enterococcus bovis* (cow), and *Enterococcus equines* (horse).

Two methods were used to assist in BST. The initial method for bacterial source identification utilized the ratio of Fecal coliform to Fecal streptococcal bacteria. In some situations, the ratio is used as a general indicator to determine the bacterial source as human, nonhuman, or mixed origin.

In the case of bacteria from mixed origin, plated Fecal streptococcus isolates were used in conjunction with CUP and a limited host-specific library (human, chicken, and dog). Because of a change in sampling partner and location after approval of the QAPP, a species library component was changed from residential/rural to residential/urban; dog was substituted for cow in the library. As the project progressed, bacterial ratios were judged unreliable and CUP was found to be a better determinant for human vs. nonhuman bacterial source discrimination.

BST determines the host origin of fecal bacteria using a database to compare environmental isolates to a limited reference library. CUP is a phenotypic gene catabolic expression method of bacterium characterization. The BIOLOG Microplates process quantifies catabolism. BIOLOG's identification system is based on the bacterial isolates ability to use a specific carbon source.

A bacterial isolate, in pure culture, is suspended into an inoculation fluid and subsequently pipetted into a 96 well microtitre plate, which contains 95 different carbon sources as well as a negative control. Carbon source utilization correlates to increased mitochondrial activity, leading to a color change in the wells and the production of a 96-well metabolic fingerprint. The resulting data, a series of positive and negative reactions, is interpreted by the BIOLOG software for identification and utilized for discriminant analyses.

Twenty-six locations in Westfield Estates and multiple grab samples were taken at each with sterile 250 ml IDEXX bottles (IDEXX Laboratories, Westbrook, ME). All samples were stored on ice in a cooler and processed within 6 hours of collection Aliquots of each sample were plated on mE agar and isolated for BIOLOG identification as described above.

Comparison of *Enterococcus* species of unknown origin with those from known organisms are used in discriminate analysis, which determines what wells are likely predictors of origin by evaluating consistency of results throughout the known library (human, dog, chicken). The predicted combinations are compared with results from unknowns to determine likelihood of fit in a particular group of origin.

Examination of samples from Westfield Estates and Halls Bayou coupled with statistical analysis of library bacterial profiles determine source as human or nonhuman (dog, chicken, unknown). Complete data tables for the BIOLOG Analysis are found in the Phase I report.

As future needs dictate, H-GAC, or its successor in subsequent phases, may need to consider examining the previously identified "hot spots" in the Community to reduce the unknown source component. CUP could be utilized to increase the isolates in the reference library and in the Community. Relatively low cost DNA sequencing could be utilized through a partnership with TAMUG. However, because it is assumed that a large portion of the unknown source component are sources that may not be feasible to address (migrating bird populations, wildlife, etc), the focus of this WPP will be on human and domestic animal/pet contributions.

Quantification of Human Health Risk

Escherichia coli are used as a predictor of the presence of waterborne human pathogens. Levels of *E. coli* in Watershed ditch water and in the bayou have been associated with human health effects recorded in the scientific literature. However, there have been no recorded incidents of large numbers of persons in the Community becoming ill with diseases associated with waterborne pathogens. An epidemiological study is needed to quantify the risk of human illness associated with exposure to bacterial contamination at levels present in the Watershed.

Statistical analysis was performed using Discriminate Analysis (DA) with SAS-JMP Statistical Software. Analysis by DA produces a classification set for every known source isolate as clusters of catabolic wells, which are compared with reference sources.

The average rate of correct classification (ARCC) is determined by averaging the percentages of correctly classified isolates for each source. Subsequently, a database is built for each known source (human, dog, chicken) and the DA compares each set of isolates from an unknown source against the database of known sources and then classifies each isolate into one of the possible sources (Graves *et al*., 2002).

Library Development

The Enterococcus library was developed from local sources of fecal material. Source *Enterococcus* isolates were collected from fecal samples of three known local Community hosts: human (five subjects), dog (four subjects) and chicken (two subjects) residing proximal to the sampling locations.

One hundred twenty isolates from each known host were sub-cultured, each isolate was gram stained, tested for catalase and oxidase activity, and streaked onto agar plates, which were incubated and subsequently analyzed for substrate metabolism and identified to species with MicroLog TM System 4.2 software. Of the 120 isolates from each known host subcultures, some were later identified by BIOLOG analysis as non-Enterococcus and removed. Composition of Source Libraries and number of derivative isolates is shown in Table 7.

Libraries in the current study were modest in comparison to recent, related work but human vs. nonhuman ARCCs compared favorably to these studies. Graves et al (2002) reported a human vs. nonhuman ARCC of 96.29% with 1,174 Enterococcus isolates using antibiotic resistance

analyses (ARA) and Hagedorn et al (2003) produced a 92.7% ARCC with 365 Enterococcus isolates using BIOLOG. Harwood et al (2000) used large (> 2,000 isolates) non-Enterococcus libraries with ARA but reported relatively low human vs. nonhuman ARCCs of 60.55% for fecal streptococci and 69.3% for fecal coliforms. Library size will be increased with Phase II work.

Recent reports have suggested that source libraries may have geographic limitations and libraries from one watershed may not be applicable to nearby watersheds (Soule et al., 2006). Therefore, the high rates of ARCC of our relatively small source library may be linked to identifying host sources proximal to sampling locations (Table 7).

Table 7: *Enterococcus* spp. Composition of Source Libraries

Source	Species	No. in Library	Percent (%) Composition
Human	*E. durans*	2	2.08
	E. faecalis	53	55.21
	E. faecium	23	23.96
	E. gallinarum	2	2.08
	E. raffinosus	1	1.04
	E. saccharolyticus	2	2.08
	E. spp.	13	12.50
	Total	**96**	100.00
Dog	*E. casseliflavus*	1	1.09
	E. faecalis	37	40.22
	E. faecium	20	21.74
	E. gallinarum	4	4.35
	E. hirae	2	2.17
	E. mundtii	2	2.17
	E. spp.	26	28.26
	Total	**92**	**100.00**
Chicken	*E. casseliflavus*	12	12.77
	E. faecalis	3	3.19
	E. faecium	9	9.57
	E. gallinarum	2	2.13
	E. spp.	68	72.34
	Total	**94**	**100.00**

Classification of Unknown Source Isolates

One hundred fifty five *Enterococcus* isolates, which included lab and/or field splits, were identified from the Westfield Estates and Halls Bayou sampling events. These were apportioned to source using the aforementioned statistical program (Table 8). In a three-way classification of pooled results, 16.0% of isolates were identified as human, 32.5% as dog, 17.5% as chicken, and 34.0% did not fit into any of the three classifications.

Table 8: Classification of Unknown Source Isolates

Classification Scheme	Known-Source Classification	Site 1	
		No. of Isolates	%
3-Way	Human	32	16
	Dog (Nonhuman)	65	32.5
	Chicken (Nonhuman)	36	17.5
	Unknown	68	34
	Total	200	100*
2-Way	Human	37	18.5
	Nonhuman	131	65.5
	Unknown	32	16
	Total	200	100*

Percent Classification of Library ARCC: 2-way Average 98.6%, 97.9% Human; 98.9% Nonhuman. 3-Way Average95.4%; 97.9% Human; 95.6% Dog; 92.6% Chicken
Cutoff for unknowns P<0.95.

A comparative analysis of the two bacterial source-tracking methods, ratio of Fecal coliform and Fecal streptococcus, was performed. Enterococcus levels in some samples were insufficient to perform CUP analysis. The comparison shows of samples from the Community and Halls Bayou with both Enterococcus and Fecal coliform/Fecal streptococcus bacteria there is very little correlation between the two methods.

Researchers from TAMUG collected 10 to 50 liters of water from each of six sites, four in the Community and two along Halls Bayou. Enteric viruses are shed in the feces of infected individuals (approximately 106 to 1010 infectious viruses per gram of feces) and enter coastal watersheds through wastewater treatment facility effluent, combined sewer overflows, which are systems that receive rainwater and untreated wastewater and overflow during high precipitation events, and leakage from high-density septic tanks (Sair et al. 2002).

There is a growing list of pathogenic viruses, collectively referred to as 'enteric viruses'. This list includes several families of viruses: (1) *Adenoviridae* (adenoviruses), (2) *Calciviridae* (noroviruses, astroviruses, caliciviruses, and small round structured viruses), (3) *Picornaviridae* (poliovirus, coxsackieviruses, echoviruses, enteroviruses, and hepatitis A virus), and (4) *Reoviridae* (reoviruses and rotaviruses) (Griffin et al. 2003). Enteric viral contamination of drinking and irrigation water sources, recreational waters, and shellfish harvesting waters pose the greatest risk to the public (Griffin et al. 2003). Enteric viruses are believed to cause the majority of waterborne illnesses (Griffin et al. 2003). Gastroenteritis is the primary manifestation of an enteric viral infection, however there is increasing evidence that enteric viruses are associated with more serious, chronic diseases such as respiratory disease, meningitis, myocarditis, and possibly diabetes (Bosch 1998).

Qualitative results for the six sampling sites showed enteric virus at all locations (Table 9).

Table 9: Detection of Human Adenovirus with PCR in Westfield Estates
(+denotes positive PCR assay; - denotes negative PCR assay)

Sample Location	Sample Date 9/18/06	Sample Date 9/26/06
Halls Bayou at Hopper Street Bridge	+	+
Halls Bayou – Foot bridge (Kowis ST.)	+	+
2500 Block of Cromwell St.	No Data*	+
2600 Block of Cromwell St.	+	No Data
2500 Block of Kowis St.	+	+
2700 Block Kowis St.	+	No Data
2700 Block of Trenton Rd.	-	No Data

*No Data = Insufficient quantities of water (50 liters) available for sample collection

It appears from this study that the largest contributors of bacterial contamination in Westfield Estates and Halls Bayou are nonhuman. This has significant impact on any correction strategy for bacterial contamination. This finding also has potential impact on corrective measures for TMDLs, whose primary complaint is bacteria levels exceeding contact recreation criteria as a result of malfunctioning OSSFs and/or malfunctioning municipal sewage systems.

Even if all the malfunctioning OSSFs in Westfield Estates were corrected, bacteria levels would not be reduced far enough to meet contact recreation criteria in all flow conditions, due to the substantial loading from nonhuman sources. All sources of bacterial contamination must be addressed in any solution proposed under the Westfield Estates WPP.

The level of unknown source of bacterial contamination is also significant. Characterization of bacterial contamination source risk factors is essential to the development and implementation of a correction strategy, since correcting contamination from only a single source, e.g. human, will not significantly reduce contamination in the Community.

Additional examination of previously identified "hot spots" in the Watershed plus additional sampling in Halls Bayou may be needed to reduce the unknown source component. Additional CUPs and relatively low cost DNA sequencing or PCR analysis are suggested as future steps if currently prescribed activities do not adequately address bacteria levels.

BST is complicated by subspecies variability, geographic location, collection time, rainfall, and habitat. Thus, the Phase I study relied on reference samples collected within the Watershed. A variety of experimental data suggests that *E. coli* subspecies are variable depending on geographical location. Bacteria subspecies related to some animals (e.g. cattle and horses) vary more with changes in geographic location than others (e.g. chicken and swine) do.

In the case of changes with time, Jenkins et al. (2003) observed that over a nine-month period, only 8.3% of ribotypes were shared at two or more sampling events for six randomly selected

cattle. Similar findings were observed for the clonal composition of *E. coli* isolates obtained from feral house mice (Gordon, 1997).

Rainfall also affects the pattern of ribotypes in *E. coli* isolates collected during stream base flow and storm flow conditions (Hartel et al. 2001). In Hartel's study on the Chattahoochee River in Georgia, 74% of the ribotypes remained unique under different rainfall conditions.

Finally, in the case of primary versus secondary habitats, evidence suggests that the clonal composition of *E. coli* changes substantially during the transition from the host to the external environment (Gordon, 2001). Whittam (1989) observed that only 10% of the 113 distinct *E. coli* clones were recovered from both chickens and their litter. A later study by Gordon et al. (2002) of two households and their associated septic tanks showed that "*E. coli* diversity … was high in one household and low in another. Thus, differences in *E. coli* clonal composition may exist between primary and secondary habitats."

5.0 LINKAGE OF POLLUTANT LOADS TO WATER QUALITY

Based on an understanding of watershed dynamics, certain activities could adversely affect water quality within the Watershed. Some sources are known, others will require further investigation. The principle pollutant is thought to be bacterial contamination. The Watershed's receiving water body, Halls Bayou, is impaired for bacteria. Possible sources of bacterial contamination are shown in Table 10.

The Westfield Estates WPP Phase I study indicates levels of bacteria in excess of State criteria for contact recreation in ditch puddles in Westfield Estates. The study also indicates that the primary sources of bacterial pollutants are dogs, chickens, and humans (presumably through malfunctioning OSSFs), and other animals or birds. All of these bacteria pollution sources are nonpoint source in origin.

Table 10: Possible Sources of Bacterial Contamination

Potential Sources	Westfield Estates	Comments
Urban Runoff	X	Impervious Cover is 40-50%
Pets	X	Primarily dogs. Number of dogs higher than the national average.
Wastewater – OSSFs	X	Failure associated with older homes/systems, multiple homes on a small lot, inadequate maintenance.
Wastewater – Treatment Plant		Plant immediately upstream of WE is within permit. Several plants two to three miles upstream of Community, at least two are out of permit. Bypasses are also possible.
Wildlife and Birds	X	On major Central Migratory Flyway route.
Agricultural Animals (Chickens, Goats)	X	Kept as pets and for food.
Feral Animals	X	Chickens, Hogs, Dogs, Cats
Illegal Dumping and Littering	X	Indeterminate
Drainage	X	Silted-in stormwater ditches allow water to pool

Correlating the level of pollutants in the Westfield Estates Watershed to water quality requires a model that approximates the dynamics within a localized watershed system. The model is used to estimate whether current pollutant loading in dry and wet weather in the Watershed meets EPA Water Quality standards for primary human contact recreation. Initial modeling provides a baseline, which allows one to measure the effectiveness of implementation measures to meet Water Quality Standard criteria.

Information on drainage hydrology, housing density, residential water flow usage, field survey for dry-weather standing water locations, population density, pet and agricultural animal

estimates, high-resolution aerial photography, flood plain maps, local knowledge, bacteria water quality analysis and other parameters contribute to model dynamics were available and used for model development.

Many sophisticated models are available to determine pollution loads in streams, bayous, and watersheds. The most widely used determinant of point source vs. nonpoint bacteria source pollutant in an open system is the Load Duration Curve. However, because of site-specific logistical dynamics and localized nature of the Watershed, none of the current models were applicable. A special Watershed Aggregate Load Determination (WALD) model has been developed to determine the pollution load within the Watershed. This model is a simplified HSPF version of the model developed for bacteria loading in White Oak and Buffalo Bayous developed for TCEQ.

5.1 Westfield Estates Watershed - Pollution Loading Model

The Watershed consists of eight longitudinal residential streets. Drainage generally flows from Aldine-Westfield Road on the western edge of the Watershed to Halls Bayou on the east side. The Watershed's northern boundary is Hopper Road, the western border is Aldine-Westfield Road, the southern boundary is Trenton Road and the eastern boundary is Halls Bayou. All streets have bar ditches rather than closed storm sewers. These ditches are routed under Shady Lane via four conduits that enter Halls Bayou. There are two additional conduits to Halls Bayou that are completely buried.

During dry weather, there is virtually no measurable flow into Halls Bayou from most of these conduits. One of the conduits is submerged and two are dry. Under moderate or high flow conditions, all drainage ditch conduits are submerged by Halls Bayou waters. As indicated in the Westfield Estates WPP– Phase I study, here are many cases of standing water in the ditches in dry weather, partly due to pools created by sediment deposition in the ditches and partly due to the many findings of OSSF failures (direct discharges or surfacing of home wastewater flows).

To approach the quantification effort, H-GAC, in conjunction with its consultant, PBS&J, has generated a representative ditch, or Community aggregate load determination, that would have sources from OSSFs, runoff flow, and bank flow. This approach is appropriate because:

- The overall area is small, about 0.35 square miles or 222 acres.
- There are 16 bar ditches for the 8 streets that are very similar as to length, dimensions, and slope.
- The ditches have a similar number of homes and documented conditions of malfunctioning OSSFs.
- The data available for each ditch is fairly limited, but if combined into a single representative ditch, is more robust.

The approach combines all the data for each ditch into a single ditch that would be represented with a simple HSPF model, with the average of OSSFs and blockages. It would be calibrated to available observed data under dry and wet conditions. The model is used to provide an estimate of approximate bacteria loads in all conditions and for a representative year.

Preliminary loading in Westfield Estates has been determined using the limited data from the Phase I study. The process will be repeated with pre-construction data as soon as it is available to provide a baseline for determining the level of success from implementation practices.

After the structural aspects of the implementation phase have been completed and the ongoing educational efforts are underway, an additional round of post-implementation sampling will be used to help ascertain load reductions. If necessary, modeling will be repeated to determine final load reduction.

High concentrations for the active runoff condition, and lower concentrations for the bank flow condition, would still exist, but with many OSSF sources removed there would be an overall reduction in the load of bacteria in the Watershed. **It is possible that the geometric mean for the number of rain days, post-rain and dry days to come out to less than 126 MPN/dL, suggesting that a primary contact criterion could be met in the ditches**. However, that result cannot be known in advance of the work. For a detailed report on loading and this model, see Appendix C.

6.0 GOALS AND OBJECTIVES

The goals of the Westfield Estates WPP are to reduce bacteria levels from human and nonhuman sources in the Westfield Estates Community to meet the aforementioned criteria and to provide for the maintenance of the achieved improvements in water quality. The objectives of Phase II of the Westfield Estates WPP (current implementation efforts) are to facilitate these goals by prescribing and implementing structural and behavioral BMPS, instituting long range management practices to maintain improved water quality, and developing awareness and Community involvement in watershed issues. These strategies should be considered interim measures, as the ultimate goal is to transition the community to sanitary sewer service and maintain ongoing education and outreach efforts through an active stakeholder group. Effectiveness of measures in load reduction in the Watershed is assessed by comparing initial bacteria levels in the Watershed with those at the end of implementation. Achievement of both goals and objectives is built on the framework of the EPA's "Nine Elements of Cause and Source of Impairment." These elements are:

1. An identification of cause and source of water quality issues
2. A projection of expected load reduction(s)
3. Proposed management measures
4. An assessment of technical and financial assistance needed
5. An information, education, and public participation component
6. An implementation schedule
7. Evaluative milestones
8. Load reduction evaluation criteria
9. A monitoring component

This WPP further specifies these goals and objectives through a series of management objectives, load reduction targets, and implementation outcomes.

6.1 Management Objectives

The management of the Westfield Estates WPP's implementation (Phase II of the Westfield Estates WPP) is based on a series of specific deliverables, including overall project objectives, target tasks for engaging the Community through education and outreach objectives, and implementation tasks.

The overall goals of implementing the Westfield Estates WPP can be described as a series of discrete, though interrelated, project objectives. As noted, these objectives are interim measures in this phase of the project, and seek to bridge the gap between acute current problems and long term ultimate solutions. These objectives are:

- Determination of any additional sources of bacterial contamination not identified in Westfield Estates WPP Phase I;
- Categorization and prioritization of malfunctioning OSSFs for replacement/repair;

- Qualification of residents for repair funds;
- Implementation of corrective action through installation of low-flow devices and maintenance, repair, and replacement of malfunctioning OSSFs and where feasible;
- Development and implementation of sustainable BMPs to reduce Community bacteria concentrations coming from both human and nonhuman sources;
- Increase education and awareness of residents on bacteria source and BMPs;
- Development of a self-sustaining stakeholder's group to continue BMPs in the Community; and
- Updating the Westfield WPP as needed during and following implementation.

Public education and outreach are necessary components to engage the Community. The Plan calls for active resident participation in the following aspects of its implementation:

- Engaging and maintaining the interest of the stakeholder base;
- Addressing proper maintenance of OSSFs;
- Implementing BMPs for nonhuman bacteria sources;
- Implementing BMPs for other WWP identified areas of concern; and
- Updating the Westfield Estates WPP as adaptive management review deems necessary.

H-GAC's management of the Westfield Estates WPP implementation project is divided into a series of tasks, each of which has clear-cut objectives and deliverables stipulated by the project contract with the TCEQ, included as Appendix D of this document. The Project tasks are:

Task 1: Project Administration and Project Management
Task 2: Implementing Stakeholders Advisory Groups
Task 3: Water Quality Monitoring, Bacteria Source Identification, Data Collection, Validation, and Determination of Effectiveness of Corrective Measures
Task 4: Determination of Management Measures
Task 5: Implementation of Structural Control Measures
Task 6: Implementation of Behavioral Measures
Task 7: Education and Public Outreach
Task 8: Watershed Protection Plan Updates
Task 9: Indicators to Measure Progress and Effectiveness of Implementation
Task 10: Final Report

6.2 Load Reduction Targets

H-GAC, SAG, and a consultant (PBS&J) used the HSPF model and currently available data to determine pre-implementation bacteria load in the Watershed (See Section 5 and Appendix C). Based on these data, the load reduction necessary to meet the primary contact recreation standard for bacteria in the linear ditches of the Watershed is a significant reduction. Bacterial levels will be updated after monitoring is completed in the pre-implementation phase of the project and adjustments made as needed to the proposed reduction. Load reduction will be calculated using the HSPF model using post-implementation monitoring data. Effectiveness of structural and behavioral measures to decrease bacteria load in the Watershed will be determined. The goal is

to reduce bacterial water quality issues from human sources below State criteria for contact recreation. This goal may not be completed under the Implementation phase of this WPP, as a long term solution for the human bacterial sources is not yet forthcoming based on financial feasibility. The eventual reduction in human-based bacterial contributions will be presumably handled by the future installation of a sanitary sewer system. In the mean time, this WPP seeks to implement interim reductions to the greatest degree practicable to help ensure improved water quality within the Watershed's linear ditches while a long-term solution is being found. Non-structural BMPs (e.g., public education and outreach, community meetings, trash reduction efforts, etc.) will form the largest part of the approach to nonhuman sources. While such outreach programs and events are often used, there is little data regarding their effectiveness in reducing bacterial contamination.[33] Therefore, specific load reductions for these sources are not presently able to be determined.

The intent of this phase is to reduce, to the greatest degree practicable given available funding, the human input from malfunctioning OSSFs in the short term and effect long term reductions in nonhuman sources, focusing primarily on pet and domestic animal wastes. The ultimate goal will be to reduce human inputs by 100% when a sanitary system is installed. Some degree of the nonhuman bacterial inputs is not currently able to be addressed (feral dogs/cats, wildlife) with current resources, or for lack of feasible management measures. Because human inputs, especially in dry conditions, can vary greatly (as standing water in dry weather is often direct OSSF outflow, or water influenced greatly thereby), the interim goal is to first address these inputs. We have the greatest degree of control over these sources, and therefore are addressing them first. Therefore our interim target goal is the reduction of human inputs as quantified in Appendix C. Our long term goal is to bring the standing water and storm flows in the Watershed's linear ditches into compliance with the Recreation Criteria.

See Section 5 and Appendix C for further information.

6.3 Implementation Outcomes

In the Westfield Estates WPP, the primary benefit from inspection, repair, remediation, installation, and/or replacement of malfunctioning systems is a direct reduction of human source bacteria in the Watershed. Identified malfunctioning or inadequate OSSFs will be prioritized based on an evaluation of 1) the worst case/highest-risk systems, 2) whether they are physically able to be remediated due to site size restrictions, etc, (i.e. whether they can be brought up to standard), and 3) whether we have cooperation from the homeowner and whether they can afford their share of the incidental costs of the remediation. These prioritizations will be aimed at getting the greatest return for money spent, keeping in mind that the ultimate goal will be to replace all OSSFs with a sanitary sewer system. Therefore, repairs/replacements will address acute problems as an interim solution. Wherever possible, low-flow water fixtures will be used to reduce flow to OSSFs, especially in areas where OSSF remediation is not possible due to site restrictions, etc. The Plan's final solution for the human source of bacteria will be the installation of a sanitary sewer system to serve the community.

[33] http://www.stormwatercenter.net/Pollution_Prevention_Factsheets/AnimalWasteCollection.htm

The interim load reduction for addressing 175 malfunctioning OSSFs is discussed in Appendix C. This phase will initiate reduction activities aimed at nonhuman sources of contamination as well. However, given the current condition of the ditches, the large acute loadings from the OSSFs and the degree of control over the OSSFs versus nonhuman (especially feral) inputs, its primary focus will be on the malfunctioning OSSFs. This information is useful for developing and implementing Watershed-wide BMPs to reduce the nonhuman bacteria water quality issues. BMPs to address nonhuman inputs will focus first on domestic animals, and then potentially address feral inputs, based on what any subsequent source tracking reveals.

Implementation outcomes include

- Repair, install, replace, or provide maintenance (including installation of low-flow devices) to 175 of the malfunctioning OSSFs in the Community (or more as funding is available, or as the progress of sanitary sewer dictates);
- Install low-flow devices where possible to reduce flows to OSSFs;
- Implement BMPs for nonhuman bacterial sources (e.g. dogs and chickens), including:
    - Educational meetings regarding pet waste;
    - Educational meetings regarding domestic animal waste;
    - Dissemination of materials to support these educational goals;
    - Investigate potential for developing a Dog Park area within local parks or installing pet waste stations therein.
    - Offering a pet/domestic animal waste reduction incentive program (e.g. compost bins for chickens, etc.)
- Hold Town Meetings two to three times per year to share progress;
- Educate stakeholders on the care of OSSFs, including maintenance agreements with FWSD; and
- Transfer “ownership” of the Westfield Estates WPP to a PSG at a Town Meeting "wrap-up” event.

Secondary benefits from the project include

- Drainage ditch maintenance in flood prone area previously hindered by presence of bacteria;
- Reduction of human illness associated with bacterial contamination, estimated by EPA at 5% of the population in the Watershed;
- Generate broad-based acceptance of a watershed-based water quality protection plan
- Reduce OSSF violations
- Reduction of nonhuman bacteria by reducing nutrient loads from OSSFs, reducing standing water utilized by wildlife (birds, etc), and reducing flow in dry weather, allowing for greater ultraviolet (UV) light exposure and resulting bacterial die-off.

Assistance to the BIG in the Metro TMDL process will also be provided. To monitor progress of Watershed remediation and its effects on Halls Bayou, bacteria levels will be determined at locations above and below the point; the Watershed drains into the bayou. H-GAC will use bacteria source identification monitoring at previously examined sites in Westfield Estates Phase I during the pre- and post-implementation parts of this project only as deemed necessary. It is expected any source identification will be only in regard to determining percentages of previously identified sources rather than trying to further define unknown sources.

Future phases (including the eventual installation of a sanitary sewer system) will be needed to meet the ultimate goals of the WPP. The timing and prioritization of future elements/phases will be drawn from stakeholder decision-making processes, and will be subject to available funding.

7.0 MANAGEMENT STRATEGIES for IMPLEMENTATION

Selecting management strategies for WPPs generally involves consideration of five factors:

- Identification of factors that influence selection of the preferred management strategies;
- Selection of the suitable approach to evaluate the ability of the management techniques to meet the Watershed objectives;
- Quantification of the expected load reductions from existing conditions resulting from the management strategies;
- Identification of capital and operation and maintenance (O&M) costs and compare initial and long term benefits;
- Selection of the final preferred strategies

In the Westfield Estates WPP, much of this process was completed in the Phase I work. Bacterial contamination is the primary water quality concern and there are a limited number of structural and non-structural strategies to address this issue. Secondary concerns regarding nutrients, trash and sediment are addressed by the same management measures as bacteria, by community events, or are handled by long–term sanitary sewer solutions, respectively. A number of strategies, both structural and non-structural were proposed in the Phase I document. These strategies, along with additional measures, have been incorporated throughout this document as appropriate in Sections 1-8 of this WPP.

Section 1 of this WPP discusses the rationale for pursuing an interim solution concurrent with a permanent solution. While a permanent municipal wastewater treatment option is being pursued by the EAMD and FWSD, it will be a mid- to long-term solution, requiring several years to put in place. Because levels of indicator bacteria in the Watershed are significant, stakeholders feel use of an interim strategy is necessary while waiting for the installation of sanitary sewer. Additionally, while the sanitary sewer will address the human sources of bacteria, additional solutions for nonhuman bacteria sources will need to be implemented regardless of the timing of sewer installation.

Quantification of current loads and load reductions for interim structural strategies are developed in Sections 3, 4, and 5. The overall goals for the implementation of the Plan are discussed in Section 6. The approach to implementing structural interim strategies is described in Section 8. These strategies will reduce the majority of bacterial contamination from human sources through structural and behavioral measures, and address the inputs from nonhuman sources primarily through behavioral measures. With human bacterial sources, primarily from malfunctioning OSSFs, the primary strategy a targeted remediation of malfunctioning OSSFs, wherever feasible, and install low flow devices to reduce influent volumes to residential OSSFs.

For nonhuman sources of bacteria, BMPs are proposed to change behavior in areas where humans have impact on the source of bacteria (e.g. pets and domestic animals.) This is a potentially difficult proposition in a community with limited resources. Education and outreach

efforts, including meetings, brochures, trash reduction events and classes, and an animal waste reduction incentive program are proposed. Section 1 presents an overview of these proposals, with additional information found in Sections 7 and 8. Modeling described in Section 5 will determine pre-and post- implementation bacteria loads as an indicator of the effectiveness of the Westfield Estates WPP's approach. It is less clear what if any BMP will be available to address bacterial contamination from non-domestic sources such as wild animals and birds. For that reason, the primary focus of the Plan will be to address known sources, with the assumption that some portion of the remaining sources is not feasible to address (migratory birds, etc).

The following sections discuss the status of current organizational strategies (7.1), current structural and non-structural strategies (7.2), the process of developing proposed strategies (7.3), and the details of the selected structural and non-structural strategies for this Plan (7.4).

7.1 Existing Organizational Strategies

The existing organizational strategies employed in the development of the Westfield Estates WPP are being regionally coordinated among related stakeholders and vertically integrated through the efforts of its various political jurisdictions and regional stakeholders.

H-GAC is a region-wide voluntary association comprised of 133 local and county governments in the 13-county Gulf Coast Planning region of Texas. Its service area is 12,500 square miles with a population of approximately 5.4 million people. H-GAC's mission is to serve as the instrument of local government cooperation, promoting the region's orderly development and the safety and welfare of its citizens.

Through H-GAC, local governments consider issues and cooperate in solving area-wide problems. HGAC Regional Water Quality Management Plan goals are to "(1) protect water resources, (2) improve water quality, and (3) ensure quality of habitats and estuaries." H-GAC manages the regions Clean Rivers Program for the region on behalf of the TCEQ.

H-GAC developed successful partnerships to fund the Westfield Estates WPP Phase I, a pilot program to determine how to reduce bacterial water quality issues in urban bayous from malfunctioning OSSFs. It is currently involved in developing rural WPPs for Bastrop Bayou, the San Bernard River, and for non-MS4 cities in the Gulf Coast Coastal Nonpoint Source Pollution Control Programs.

H-GAC is the managing stakeholder for the BIG for TMDLs currently underway in its region. The Watershed is located in the Houston Metro TMDL area. This WPP is consistent with the goals and objectives of the TMDL. TCEQ TMDL section is included in the review process for QAPPs for the Westfield Estates WPP.

Regional stakeholder meetings organized by H-GAC in 2003-2004 on OSSF issues led to a grant from GBEP to measure bacteria levels in Halls Bayou resulting from malfunctioning OSSFs (Westfield Estates WPP Phase I). The project partnership expanded to include HCPCT2, HCPID, the FWSD, TAMUG, local citizens, and the media.

In-kind services provided by the stakeholders included county database information, assessment/prioritization of Community/countywide needs, lab analysis, public relations, translation of materials, contacts, and generation of stakeholder interest.

Two studies funded by HCPCT2 ($300,000) assessed needs and possible remedies in OSSF communities including Westfield Estates, and provided key information used in the WPP.

HCPCT2 also provided public relations and translation support for the Westfield Estates WPP Phase I public meeting (est. $5,000) and FWSD provided notices in water bills (est. $2,000). Over 100 interested parties attended the first Town Meeting on the WPP and bacterial water quality issues in the Watershed.

This level of official and public involvement will assist in preparation and implementation of BMPs, acceptance of the WPP strategies, and allow work to progress toward long-term solutions to the bacterial water quality issues.

As Sections 2.4 of this WPP indicates, HCFCD, and the GBEP have plans in place for areas that include the Watershed. Neither is directly applicable to the reduction of bacterial water quality issues in the Watershed. Harris County is currently implementing a bacteria reduction plan for area waterways that was adopted by their Commissioners Court in July, 2008. The Westfield Estates WPP will compliment the Harris County plan and is expected to further reduce bacterial water quality issues in the area. These existing cooperative organization strategies serve as a model for future efforts.

7.2 Existing Controls

7.2.1 Structural Controls

At present, structural controls for managing human bacterial input/waste are limited to the Community's OSSFs, many of which are malfunctioning or inadequate. There are few if any controls for domestic or feral animal wastes. Some Watershed residents cage their chickens and other domestic animals, while others allow them to roam freely. Some residents keep their pets, primarily dogs, within fenced yards. However, animal waste is primarily left on the ground to decompose and wash into adjacent drainage ditches. Under the Westfield Estates WPP, the specific location of functioning structural controls will be determined by survey in FY10 and engineering evaluation in FY10 – FY11.

Area drainage ditches are clogged and silted in at several locations, which hinders pollution reduction. A great deal of surface area is covered by impervious surfaces in the Watershed including roads, driveways, home and business footprints, and parking lots. Impervious cover the Westfield Estates is greater than 45% of the surface area, which substantially facilitates the increase in pollution load in the Watershed and puts further strain on existing structural controls (e.g. drainage ditches).

7.2.2 Non-structural Controls

Non-structural controls in the Watershed include county permit requirements for installation of new OSSFs. Visual inspection of current Watershed OSSFs is conducted by Harris County on a periodic basis and violations are recorded. Since many of the residents lack resources to maintain their systems, violation citations frequently are ignored. Justice of the Peace courts are hesitant to force people out of their homes for failure to comply with ordinances because of low income.

There are no BMPs in place to reduce pollutant load by requiring owners to collect their pet waste and dispose of it properly or to cage chickens. The watershed currently lacks any significant nonstructural controls to effectively reduce pollutant loads,

7.3 Development of Proposed Management Strategies

The development of the water quality management strategies as presented in this Plan utilized Phase I work as a base, proposing both interim and long-term solutions. Extensive stakeholder input and participation was used to further refine these proposed strategies and select a final roster of BMPs.

The ultimate solution for the human bacteria source is the installation of sanitary sewer service (likely from the FWSD/EAMD). However, the intervening years before such a solution could be enacted necessitate interim solutions. The Plan calls for mitigation of current on-site system problems and implementation of BMPs for OSSFs and nonhuman sources to run concurrent with efforts by major stakeholders towards finalizing the permanent solutions.

The magnitude of the Westfield Estates problem is such that no single stakeholder can manage the entire issue independently. Community-wide support, including cooperation from elected officials, businesses, county and state agencies, is required. Possible changes in substance and/or enforcement of current regulations, ordinances, and permit requirements might be considered. The development of the proposed measures also included a series of public outreach events and a town meeting to disseminate information and consult with stakeholders. (See Section 8, Public Outreach and Community Development.)

The status and needs of the community were assessed through a series of field reconnaissance and public meeting outreach efforts. Pertinent concerns, issues, and logistical challenges that arose from this stakeholder involvement process were considered and weighed in order to develop a final roster of management measures,

Interviews with several homeowners during the field reconnaissance and local meetings indicated that residents thought municipal sewer systems would be a welcome, long-awaited addition to the Watershed. Most were pleased with the recently installed municipal water system which was funded through community block grants, although some residents opted not to hook up to the water system. Although most residents queried in the field, and the majority of those at the town meeting, indicated they would like to receive sewer service, they were unaware of the

potential need for and use of interim solutions to the bacterial contamination problem. Most were concerned about having their ditches maintained to prevent the occurrence of standing water in front of residences. While this is a reasonable concern, proper ditch maintenance alone would not decrease bacterial contamination from waterborne pathogens in the Watershed. Ditch maintenance may in fact give residents a false sense of security about the presence of pathogenic bacteria in the Watershed.

Homes continue to be built in the Watershed. Several homes that had fallen into disrepair have been remodeled and offered for sale by either owner or realtor. Some are on reasonably sized lots to accommodate aerobic OSSFs. Others are crowded together on extremely small lots, which barely meet, or fail to meet, minimum permitting requirements. Often there is more than one residence on the single lot, which circumvents the permitting process. There is some evidence that recent OSSF installation at new construction may not conform to Harris County design and inspection criteria. At the Town Meeting and in a subsequent phone conversation, one resident indicated his new aerobic system left his back yard so wet his children could not play in it. His neighbor's yard received spray from his system. County permits are required for all new construction. Obviously some builders do not abide by these covenants.

There is no overall governing body (like a HOA) specific to the Community. However, there are a variety of governmental bodies that have jurisdiction over the area, including the aforementioned EAMD, HCPCT2, and FWSD. Local outreach groups like Talento Bilingue de Houston, an environmental outreach-oriented Latino group, have expressed interest in serving as liaison between the organizing entities and the Latino community in the Watershed, and several local community organizations. These organizations include the George Foreman Youth and Community Center, Principe de Paz Church, The Church of the Lord Jesus Christ, Templo De Ponder, and St. Luke's Lutheran Church. Additionally, a local grocery store that many residents visit on foot is also a logical site for distributing BMPs for OSSF information. The Northeast Community Center is also an excellent facility, located close to the Community, and available for meetings. The availability of technical expertise among the stakeholder group, potential venues, and local community organization capacity all informed and shaped the selection of the final management strategies.

The overall strategy for reducing bacteria in the Watershed, after taking all these elements into account, revolved around two categories of bacteria sources. For human sources, the bacteria contributions are coming primarily from fixed locations (OSSFs). Therefore structural remedies were feasible. Non-structural/behavioral remedies aimed at raising awareness, and fostering proper OSSF maintenance were a necessary complement to these activities. The mix of low-flow installations and targeted OSSF remediation evolved as the timing for a permanent sanitary sewer solution became more solid. The stakeholders felt that interim solutions should strike an overall balance between tackling the acute bacteria issue while at the same time recognizing a permanent solution would make some remediative efforts inherently temporary.

Nonhuman sources in the Watershed are more diffuse (mobile pets/domestic animals) or unfeasible to address (wildlife). These nonhuman sources that can be addressed are primarily linked to human behavior (how pet waste is handled, etc). Therefore, the stakeholders felt that

the general strategy to address the sources should incorporate behavioral management strategies and education/outreach.

7.4 Selected Management Strategies

To ensure a balanced approach that addresses the variety of bacteria sources in the watershed, a comprehensive suite of management strategies were chosen. Based on this process of strategy development, structural (section 7.4.1) and non-structural (Section 7.4.2) management measures were selected by the stakeholders. As described in the following sections, each category of management measures has both an interim and long-term component, as further detailed in the implementation strategy and timelines of Section 8. The implementation of these management measures will provides the basis for the WPP to achieve this desired results in accordance with the nine elements of the EPA Watershed Protection Plan.

7.4.1 Structural Management Strategies

The selected structural management strategies focus on managing bacteria from human sources. Additional measures and strategies will be required to reduce nonhuman bacterial contamination in the Watershed. However, because nonhuman sources are more diffuse and/or transitory, the focus of structural controls in this Plan is on malfunctioning OSSFs. Nonhuman sources will be addressed primarily through behavioral measures.

The implementation of this WPP will entail several structural management measures, including targeted survey/inspections of malfunctioning OSSFs in coordination with low-flow device installation, subsequent design plans for sites able to be remediated, development of resident qualification and site prioritization criteria for OSSF remediation, and a review of current regulatory efforts aimed at curbing OSSF violations. The strategies discussed herein are summarized in Table 11, at the end of the subsection.

Because of the number of unknown factors at this stage of the implementation process, it is difficult to project whether the current implementation budget's funding under Phase II will be sufficient to repair all of the OSSFs that need to be addressed. This will be heavily dependent on current construction/services pricing, results of the OSSF prioritization process, community/ homeowner buy-in, and the timing of the municipal sanitary sewer project. There may be sufficient funding to achieve desired load reduction. If there is insufficient funding, desired load reduction may not be achieved in Phase II, but will continue to be the end goal of implementing this Plan. Stakeholders are prepared to go forward with seeking additional grants if this is the case.

The following are the selected interim and permanent structural strategies, categorized by whether they address human or nonhuman sources. The human structural strategies are further divided into interim and permanent strategies.

Human Source Structural Management Strategies - Interim

With municipal sewer service unavailable for at least several years, current options to reduce human bacterial contamination from OSSFs include proper maintenance, corrective measures

where possible, and strict enforcement of permit requirements for new or remodeled construction. BMPs will reduce and minimize human exposure to bacteria and bacteria loading in the Bayou from human sources.

- **Targeted remediation of malfunctioning OSSFs -** The primary source of human bacteria in the Watershed is malfunctioning OSSFs, which are the primary focus for interim structural controls under this Plan. It is anticipated that malfunctioning OSSFs will be addressed by different measures dependent on the specific situation. Some facilities may need minor repair, some major repair, and yet others pump out or replacement. Because the project will complete a significant number of repairs/installations, it is anticipated that reduced pricing for each activity could be negotiated/available, increasing cost effectiveness. Another consideration is the need to maintain the OSSFs once repaired, pending eventual municipal service. To receive facility repairs or new systems, residents will be required to agree to a maintenance agreement, which will be managed by the FWSD. Since the FWSD currently serves Westfield Estates with potable water, OSSF maintenance fees will be added to the water bill. The FWSD will adopt a rate order change to allow this practice, if necessary. This is a cost effective method; maintaining a large number of OSSFs will cost less than individual maintenance. 319(h) funding may be a potential future means to maintain this program. HCPID will complete initial site inspections and surveys, EAMD will oversee construction/remediation activities, FWSD will create and maintain maintenance agreements with the OSSF owners, and H-GAC will provide project oversight and outreach along with HCPCT2 and TBH. Maintenance will be performed, as per state requirements, by licensed staff, whether from the FWSD or a third party service. Criteria for resident qualification site prioritization, as well as other criteria and procedures necessary to implement and manage these processes will be developed by the stakeholders.
- **Installation of low flow devices** – water conservation devices will be installed, where possible, in residential homes throughout the watershed to decrease the inflow to OSSFs. This in turn will help prevent overflows of malfunctioning OSSFs. It is expected that the low flow devices will contribute to bacteria reduction goals, but the modeling of reductions does not include this assumption, as the extent of the benefit is highly dependent on the state of the OSSF. Additionally, while there is ample data regarding the volumes of water to be saved by low-flow devices (faucet aerators, toilet tank dams, low-flow showerheads, etc), there is little information available regarding the employment of these devices to reduce flows to residential OSSFs. However, given the low cost of this alternative versus physically remediating a larger number of OSSFs (which will be inherently temporary improvements, in expectation of sanitary sewer), the general condition of many of the sites in the watershed (unsuitable for OSSF remediation), and the additional benefits of reducing water consumption and related cost, the stakeholders felt that this strategy was a good complement to remediating OSSFs. Additionally, these devices may help prevent further degradation of OSSFs that are not yet malfunctioning, but which are over-taxed or under-maintained.

Human Source Structural Management Strategies – Permanent

The single most viable long-term solution to the human bacterial contamination in the Watershed is municipal sanitary sewer service. As the City of Houston has no current plans to annex the Watershed, the assumed provider is the FWSD, via investment in capacity and collection system infrastructure made by the EAMD.

- The ultimate solution to the human bacteria sources (malfunctioning OSSFs) in the Watershed would be to provide service to the residents from a FWSD wastewater treatment plant. Plans to serve the Watershed require expanding the current wastewater treatment plant, adding two lift stations, sanitary sewer lines, and connection lines from the street to residences and businesses. The initial cost estimate for this solution was $16 million for engineering, construction, and road repair. Additionally, this process will need to consider concurrent changes to Halls Bayou (by HFCD, etc al) and any issues this may raise for plant/infrastructure siting. Funding will most likely come from a mix of federal, state and local grants, funds, and loans. While this Watershed is the highest wastewater treatment service priority for HCPCT2, funds may not be available in the foreseeable future. FWSD has limited authority to issue bonds or contract loans. Further, U.S. Census demographics indicate Watershed residents may not be able to easily shoulder the expense of loan repayments. Environmental justice issues apply to the Watershed. Funding sources in this area may be available to implement this program (refer to funding sources – permanent solutions). The permanent solution would include a requirement or incentive for the residents to switch their service over to a new sanitary service.

Nonhuman Source Structural Management Strategies – Interim/Long Term

The solutions for nonhuman sources of bacteria are primarily focused on behavioral modification in this Plan (Section 7.3.2). However, there is an opportunity to implement a pilot program(s) to address pet waste in the community. The following program development will be part of the Plan implementation.

- Create and implement a pet waste reduction incentive program to investigate local interest in activities like chicken waste composting, pet waste collection materials, etc. The community/stakeholder interest will decide what elements are funded as incentives under this program, and may include cost-share or direct funding of small pet waste related items (Chicken waste composting bins, dog waste cleanup supplies, etc).
- Investigate, with HCPCT2 and other stakeholders maintaining local parks, the potential to set aside space in a neighborhood park or open space area for a dog park or dog zone, or considering installation of pet waste stations. These discussions will take place with HCPCT2 and H-GAC, and will be ongoing.

Additionally, ongoing renovation of Halls Bayou and potential remediation of siltation in the linear ditches of the Watershed (for which there are no currently scheduled plans) could potentially be employed in the future. In that case, the impact of nonhuman bacteria in the linear ditches would be lessened (due to flow being less subject to restriction and resultant pooling).

Funding Sources—Permanent Solutions

The economic burden for the permanent structural solution is substantial, approximately $16 million according to HCPCT2's recent study. Because the permanent solution stands to be a

joint effort between two or more stakeholders, and the public outreach focus of its implementation may fall to the PSG or other community group, there may be a role for these groups in helping to identify and secure grants or other funding sources in support of the infrastructure or education measures. Potential sources of funding for the project, with requirements, are listed below. Some of the sources may also be useful in establishing ongoing nonstructural programs and measures.

EPA State and Tribal Grants (STAG)
These are special appropriations grants, which require up to a 45% match from local sources. Approximately $200 million was awarded through these grants in FY2006, ranging in amounts from $50,000 to $5 million, with an average grant amount of $780,000. Funds must be requested no later than August each year with award date in November.

Texas Water Development Board (TWDB) Economically Distressed Areas Program (EDAP)
Funding may cover up to 75% of the project. The applicant must be capable of operating and maintaining the infrastructure. Community median household income must be less than 75% of the state median household income.

Housing and Urban Development's Community Development Block Grant (CDBG) Program
Approximately $7 million were available in FY2006. Applications are due in July of each year.

TWDB Water Supply and Wastewater Facilities Planning Program
Funding may cover up to 50% of the project's cost. It is available to political subdivisions that can plan, develop and operate facilities.

Department of Commerce Public Works Economic Development Program
This funding source covers up to 50% of project costs, with approximately $205 million awarded in FY2004. Awards ranged from $59,000 to $6 million, with the average being $1.4 million.

TWBD Clean Water State Revolving Loan Fund (SRF) Program
This program has up to $75 million available for loans that can be awarded during the first nine months of the fiscal year. Maximum time for repayment is twenty years. Applications are accepted continuously.

TWDB State Loan Program Texas Water Development Fund II
The process and awards are similar to the other SRF program. Applications are accepted continuously.

TCEQ Supplemental Environmental Projects (SEPs)
TCEQ Supplemental Environmental Projects result from administrative penalties. Violators have the option of offsetting a portion of an administrative penalty into a SEP. These projects are applied for by local governments, non-profits, and political subdivisions, and when approved by TCEQ, are funded as administrative penalties from violators are disbursed into SEPs. Funding and amounts are not guaranteed. Applications are accepted continuously with funding as the moneys become available.

Structural Management Strategy Success Indicators

Post-implementation monitoring, number of OSSFs remediated, and number of houses retrofitted with low-flow devised will be the primary indicators of structural BMP success. It is anticipated this will be a significant reduction in human source bacterial loading (with the bulk of nonhuman loading addressed via non-structural strategies). However, this Plan recognizes that elimination of some human sources may make implementation testing more difficult. OSSFs are identified as the primary source of standing water in ditches in dry weather. The remediation of the OSSFs may reduce flows or eliminate standing water in the ditches which in turn makes dry weather sampling more difficult or impossible. In fact, part of the measures of success for the BMPs recommended is a reduction in standing water at these sites. However, sampling sites pre- and post-implementation of management measures will attempt to align, to the greatest extent practicable, with the previously sampled locations.

Table 11: Structural Management Strategies

Pollution Source	Strategy	Scope	Type	Schedule	Responsible Party
OSSF	Investigate OSSFs	Up to 450-500 homes	On-site investigation (interim)	Summer-Fall 2010	H-GAC, HCPID
OSSF	Develop Site plans	Up to 175 OSSFs depending on funding	Planning (interim)	Summer-Fall 2010	H-GAC, HCPID
OSSF	Remediate OSSFs	Up to 175 OSSFs depending on funding	Construction (interim)	Fall 2010-Summer 2011	H-GAC, EAMD
OSSF	Install low-flow devices	Where feasible, according to funding/site plans	Supplement to OSSF remediation (interim)	Summer 2010-Summer 2011	H-GAC, EAMD, FWSD
OSSF	Install sanitary sewer	Entire Community	Construction (permanent)	Finalize study – Summer 2010 Authorize Inter-local Agreement – Summer-Fall 2010 Construct additional capacity – 1-2 years Construct Westfield collection system – unscheduled.	Formal roles unknown at the time (HCPID, HCPCT2, FWSD, EAMD, H-GACPAC)
Pet Waste	Investigate dog park area/pet waste stations	Community-wide	Planning	Ongoing	H-GAC, HCPCT2 and other entities operating local parks as feasible.
Pet Waste/ Domestic Animal Waste	Animal waste reduction program	Pet/domestic animal owners	Provision of supplies, potential installation	Winter 2010-Summer 2011	H-GAC, HCPCT2, EAMD

7.4.2 Non-Structural Management Strategies

Non-structural management strategies include BMPs which often attempt to modify the behavior of residents in the watershed who have control over some aspect of the cause of bacterial water quality issues in and around their homes. The strategies selected for incorporation into this Plan include education and outreach about care and maintenance of OSSFs, pet and domestic animal waste, and trash reduction. Unlike the structural strategies, the non-structural strategies are not clearly defined as interim and permanent measures because they will run concurrently and continuously with both phases of the structural strategy approach. The management strategies discussed herein are summarized in Table 12 at the end of this subsection.

The most directly targetable source of bacterial contamination in the Watershed is the malfunctioning OSSFs. However, large portions of the bacterial load are not related directly to human sewage, including family pets, animals kept for food purposes and wild animals/birds. While the contribution of bacterial contamination from humans is significant (16%), one cannot overlook the contribution from nonhuman bacterial sources such as dogs (33%), chickens (17%), and unknown (34%). Watershed-wide consensus and action on nonhuman sources are necessary to reduce the level of bacterial contamination from dogs, chickens and other nonhuman species in the Watershed to a level that will achieve state criteria for contact recreation.

In the Watershed, Phase I studies identified dogs and chickens as primary nonhuman contributors to bacterial water quality issues of the Watershed. While structural management strategies are aimed primarily at remediating malfunctioning OSSFs, non-structural BMPs will be used to supplement efforts to reduce loading from OSSFs (via education and outreach) and attempt to change behaviors that lead to pet and domestic animal waste loading. The primary methods of affecting behavioral change will be conducting educational meetings, distributing educational materials, and holding public events (kickoff event, etc.).While similar programs are widely used in watershed protection efforts, there is little data regarding the loading reductions they may produce. [34] Additionally, trash in the ditches will be addressed, both for its aesthetic effect and for the effect it has on water pooling in the ditches. While there is no direct load reduction for remediating trash issues, doing so allows other management strategies to operate effectively.

In Phase I of the project, the stakeholders worked to develop strategies, utilized data analysis, underwent risk assessment, and considered the incorporation of non-structural BMPs aimed at remediating bacterial loading from OSSFs and nonhuman sources, promoting general Community awareness of watershed issues, and reducing related concerns in the Watershed (trash).The following is a recommended suite of non-structural management strategies. When the Plan is approved and public input is sought during the implementation phase of the project, or when more effective strategies are available, these strategies may be modified in future Plan updates. H-GAC will organize and implement these strategies with assistance from the HCPCT2, TBH, FWSD and EAMD on select events/efforts.

[34] IBID.

Human Source Non-Structural Management Strategies

These strategies will be used in conjunction with the physical remediation of OSSFs discussed in the previous section. The following non-structural management strategies are recommended for helping to reduce human bacterial loading:

- Hold educational meetings regarding OSSF care and maintenance, targeting Watershed residents. These public meetings would serve as a direct point of contact for the residents, and allow for dissemination of materials at the same time. One meeting annually will be scheduled in the Community, beginning in 2010. The effectiveness of the meeting will be gauged by the participation from the Community and an in-class survey. Local churches or the Northeast Community Center, located adjacent to the Watershed, are likely venues for such meetings.
- Disseminate and make available educational materials, in English and Spanish, regarding OSSF care and maintenance. These materials will include online resources, printed materials, and broadcast materials as funding and opportunity allows. These materials will be produced and disseminated on an ongoing basis. The effectiveness of these materials will be judged by change in knowledge on a general community wide survey.

Nonhuman Source Non-Structural Management Strategies

These non-structural strategies will target nonhuman bacterial sources, and will be the sole strategies for dealing with these sources under this phase of the Plan. These efforts will include:

- Holding educational meetings regarding pet waste, targeting Watershed residents. These public meetings would serve as a direct point of contact for the residents, and allow for dissemination of materials at the same time. One meeting annually will be scheduled in the Community, beginning in 2010. The effectiveness of the meeting will be gauged by the participation from the Community and an in-class survey, and observable decreases in bacteria levels from this source.
- Disseminating and make available educational materials, in English and Spanish, regarding pet waste. These materials will include online resources, printed materials, and broadcast materials as funding and opportunity allows. These materials will be produced and disseminated on an ongoing basis. The effectiveness of these materials will be judged by change in knowledge on a general community wide survey, and observable decreases in bacteria levels from this source.
- Attending local meetings and events to discuss pet waste with residents in support of these efforts, on an ad hoc basis.
- Holding educational meetings regarding domestic animal waste, targeting Watershed residents. These public meetings would serve as a direct point of contact for the residents, and allow for dissemination of materials at the same time. One meeting annually will be scheduled in the Community, beginning in 2010. The effectiveness of the meeting will be gauged by the participation from the Community, an in-class survey, and observable decreases in bacteria levels from this source.
- Disseminating and making English and Spanish educational materials available, in, regarding domestic animal waste. These materials will include online resources, printed materials, and broadcast materials as funding and opportunity allows. These materials will be produced and disseminated on an ongoing basis. The effectiveness of these

materials will be judged by change in knowledge on a general community wide survey, and observable decreases in bacteria levels from this source.

General Watershed Non-structural Management Strategies

These strategies are designed to promote general watershed-wide goals that are not specific to any given source. They seek to promote other goals by fostering resident involvement, and are not necessarily tied to a direct load reduction.

- Public Meetings will be held on a regular basis throughout the implementation process. Starting with a kickoff meeting in conjunction with entertainment and education efforts by TBH (fall 2010), direct input and involvement to residents will be cultivated through open meetings and SAG involvement. Effectiveness of this strategy will be measured by participation and knowledge change as evidenced by post-implementation surveys.
- Targeted community surveys will be conducted prior to, and following, implementation activities. The survey will seek to ascertain the impact of educational activities, the concerns of the residents, the status of problems in the Watershed, and need for adaptive management review of the Plan. The survey will be administered in fall 2010 and following implementation through fall of 2011.
- Trash reduction in the linear ditches will have aesthetic and hydrologic benefits. One trash reduction event, in 2010, will seek to clear the ditches of all large debris and other refuse. This will allow freer flow of stormwater and engender resident involvement. The event will be repeated if necessary and/or funds allow and stakeholders are interested in doing so. Measures of success for this strategy will be the observable decrease in trash in the ditches. No direct load reductions will be measured for this event.
- Establish regular meetings of the Stakeholders Group to continue to find a permanent solution for the Community, which will be fully embraced by the residents. This strategy will help with the implementation of other strategies by enduring the process continues to be a local stakeholder-led effort.

Non-structural Management Strategy Success Indicators

Success will be measured by reduction of specific anthropogenic bacterial loading in the Watershed, including *E. coli*, and decrease in bacterial contamination from other identified species (canine, poultry, and others). Indirect measures of success, as discussed in the strategies outlined above, will involve participation by the Community and change in general watershed knowledge.

Stakeholder Involvement

Individual Homeowners

Although most residents queried in the field and the majority of those at the town meeting indicated they would like to receive sewer service, they are currently unaware of the need for and use of interim solutions to the bacterial contamination problem with regard to pets (e.g. chickens and dogs).

Education explaining the link between unrestrained pets and bacterial contamination is needed. This must be followed with information on how to address each of these issues: restraint of pets and picking up pet waste.

Public Outreach and Community Involvement
Outreach and education activities strive to raise the awareness of possible risks to human health and the environment from bacterial contamination from human and nonhuman sources (dog, chicken) in the Watershed. Target audience includes residents of local and regional communities, elected officials, realtors, developers, businesses, and other stakeholders.

Outreach activities progress in stages. They begin with informal interaction with stakeholder and public participation. The idea is to provide the public with balanced and objective information to assist citizens and stakeholders in understanding the problems, alternatives, and solutions. Fact sheets, websites, and open houses are integral parts of outreach here.

The second stage is to consult with the public to obtain public feedback on analysis, alternatives, and possible solutions. Here the goal is to listen, acknowledge concerns, and provide feedback on how public input influences the ultimate decisions. This is achieved through public comments, focus groups, surveys and public meetings.

Public outreach moves to involve the public in the problem-solving process in its next stage. One works directly with the parties throughout the process to ensure that public issues and concerns are consistently understood and considered. Workshops and deliberate polling ensure that public concerns and issues are directly reflected in the alternatives developed. They provide feedback on how public input influenced the decision.

In the collaborative stage, a partnership is developed between major stakeholders and the public in each aspect of the decision, including the development of alternatives and identification of the preferred solution. Activities at this stage include citizen advisory committees, consensus building, participatory decisions, and making charrettes.

Finally, the stakeholders empower the public to determine the ultimate solution to the problem. Implementation is based on public decision determined by citizen juries, ballots, and/or delegation.

Information and processes developed in this outreach activity are directly applicable to other on-site septic facility communities in the region. As with other similar watershed protection activities, long term success will be dependent on continuing commitment and involvement on behalf of the Community. Outreach activities should seek to engage the residents and facilitate their eventual leadership role in the Community.

Information Sharing, Consultation, and Partnerships
The WPP proposes implementing an integrated watershed and stakeholder involvement program for information sharing and consultation, representing stages one and two in the outreach program. These activities are designed to increase awareness about the extent of the bacterial contamination in the Watershed, educate municipal officials and citizens about threats to human health and water quality arising from nonpoint source bacterial pollution, and increase interest in the formation of a watershed stakeholder group.

Understanding malfunctioning OSSFs and other nonhuman sources of bacterial contamination and their links to residents' quality of life and health, ecological health of area water bodies, and ultimately local economics is a necessary foundation for developing outreach stages three through five: problem solving, partnerships, and empowerment, which culminate in a successful correction strategy.

Education and outreach activities occur through a variety of strategies. Informal meetings and conversations with stakeholders will occur throughout the course of the WPP development and implementation. Staff listened and responded to residents during field reconnaissance in order to open dialogue, and assess the stakeholder base within the area. As information was developed, more was forthcoming as other stakeholders commented on information. One-on-one conversations and small group meetings (e.g. FWSD) were held. Some of the stakeholders who provided input included:

- HCPCT2 - Commissioner Garcia, executive staff, community liaisons, consultants (Camp Dresser & McKee, Inc.), public relations, staff at community center, public infrastructure staff;
- FWSD - Board of Directors, attorney, engineer, district manager;
- Harris County - HCPID, Public Health and Environmental Services, and County Attorney's Office;
- EAMD - Consultants;
- City of Houston - Health and Human Services;
- TCEQ - TMDL Team, Region 12 Water Section;
- TAMUG - Department of Marine Sciences;
- Baylor University, Department of Environmental Studies;
- NRAC, H-GAC Board of Directors, and
- Residents (Field reconnaissance, FWSD meetings, town meetings, and follow-up requests). Presentations were also provided for a number of stakeholders and interested parties as a result of the Phase I study. These activities provide a basis for the Phase II work.

Public Meetings

H-GAC, in conjunction with its partners, hosted a public town meeting as part of the Phase I project to discuss project goals, monitoring data analysis, assess perceptions about threats to human health, and determine environmental awareness, related values, attitudes and traditions. Exploration of the relationships between land use, watershed health, and sustainable economic development options were also discussed.

Specific agencies and offices invited to the public meetings included HCPCT2 Commissioner Sylvia Garcia's Office, Texas State Senator Kevin Brady's Office, EAMD, FWSD, Harris County Attorney's Office, HCPID, Harris County Public Health and Environmental Services, TCEQ Region 12 Water Section, and the GBEP.

Promotion for the meeting included 1,700 notices in January water bills courtesy of FWSD, 800 notices via the Northeast Community Center mailing list, fliers posted in approximately 30 area businesses and at the Community Center, press releases to many English and Spanish-speaking

newspapers, and television media (English and Spanish), H-GAC mailing list for the NRAC of the Board of Directors, H-GAC Community and Environmental Planning Department News Letter, and H-GAC Press release.

It was necessary to conduct two rounds of promotion for the meeting because the first meeting scheduled in January was cancelled because of inclement weather. A summary of meeting attendance and outreach dates, locations, topics, and numbers of attendees is included in this WPP.

H-GAC also compiled electronic photographs and images (maps and figures) for use in public meetings as well as to illustrate the location of the Watershed, threats to the Watershed and human health from bacterial contamination, and other relevant activities. A similar process will be utilized for Phase II.

Outreach Brochures

Other tools used to assist in education and outreach were the OSSF Problem Correction brochures. Because of the large number of Non-English speaking or English-as-second-language persons in the Community, H-GAC used an EPA manual for OSSF care and maintenance and an EPA "Flush Responsibly" reminder card, which were translated into Spanish. The manual and card, in both English and Spanish, were disseminated within the Watershed, to other H-GAC OSSF communities, and at regional conferences, workshops and symposia. These brochures will also be placed on the H-GAC and other appropriate web sites.

Brochures in English and Spanish were distributed at the Phase I Town Meeting (250), with an additional 150 pieces of informational material left at the Northeast Community Center. Brochures were distributed at an additional four Precinct 2 Town Meetings in other areas, GBEP State of the Bay Symposium, and H-GAC NRAC meeting.

H-GAC is currently involved in the Hurricane Ike Recovery program. Many affected homeowners in the GBEP region use OSSFs. Staff provides copies of these brochures to all contacts.

The brochure and Outreach CD are available on the H-GAC website (www.h-gac.com)

OSSF Public Information CD

H-GAC developed an inclusive resource for addressing public, business, and local government concerns with malfunctioning OSSFs. The Resource CD includes a Glossary of Terms, Public Outreach Templates for Local Communities, Funding Sources for Remediation, Information for Homeowners, Resource Organizations, and Information for Realtors, Regulation and Enforcement, Suggestions for Small Communities, Technical Information, Texas Programs, and Frequently Asked Questions. A detailed list of materials found on the CD is listed in the Appendices of this WPP.

Permanent Stakeholders Advisory Committee
A sustaining local stakeholders advisory group (The PSG) will be necessary to address bacterial contamination in the short and long term. The group should include homeowners and residents from the Watershed, a wide spectrum of resource agencies, elected officials, and local businesses, especially realtors and builders.

Support provided by HCPCT2 includes providing a location for stakeholder meetings, assisting with the dissemination of outreach material, supporting plans to implement BMPs to control bacterial contamination, supporting plans for a permanent solution to bacterial contamination in the Watershed and other parts HCPCT2, and offers to supplement future water quality monitoring efforts through sharing data collected on the Watershed from County sources.

The FWSD will ultimately be responsible for providing municipal sewer service to the Community. Since it already supplies water to almost the entire Community it is also a good partner to work with HCPCT2 in dissemination of information and in implementing interim corrective strategy. It is possible both entities can pursue sources of funding for the final solution to bacterial contamination in the Community, which then flows into Halls Bayou.

HCPID is also in a position to provide assistance because of their engineering expertise, monitoring, and survey capabilities.

The Houston-Galveston Subsidence District has a program to reduce use of ground water, involving retrofitting appliances for water conservation. The materials and resources available from that program might be useful in this situation.

Pursue Funding Sources
BMP solutions to bacterial water quality issues in the Watershed require continuity and support to ensure continued success. Because of substantially different grant and loan requirements, and logistical and jurisdictional issues, an active and effectively integrated PAC will be necessary. Application coordination and support will also be required for funding for additional structural controls if necessary. Watershed outreach will be necessary so that residents embrace the municipal sewer system when it becomes available. H-GAC proposes to act as coordinator for the outreach activities and stakeholders group with funding provided by TCEQ for this staffing activity.

The Watershed may also qualify for Environmental Justice funds or TCEQ SEP funds, both of which could be sought to implement new BMPs if the need arises.

Table 12: Non-Structural Management Strategies

Pollution Source	Strategy	Target Audience	Type	Distribution	Feedback/ Evaluation	Schedule	Responsible Party
Pet Waste	Educational Meeting	Community members	Public meeting	In person, with materials	Survey during class	Annually, 1-2 hours	H-GAC, HCPCT2, TBH
Pet Waste	Educational Information	Community members	Publication	Distributed (mail, handouts, online)	Survey	Ongoing	H-GAC, FWSD, HCPCT2, TBH
Pet Waste	Presence at local events	Community members	Various public events	Materials and in person	General Comm. Survey	Ad hoc	H-GAC, HCPCT2
Domestic Animals	Educational Meeting	Community members	Public meeting	In person, with materials	Survey during class	Annually, 1-2 hours	H-GAC, HCPCT2, TBH
Domestic Animals	Educational Information	Community members	Publication	Distributed (mail, handouts, online)	Survey	Ongoing	H-GAC, FWSD, HCPCT2, TBJ
OSSF	Educational Meeting	Community members	Public meeting	In person, with materials	Survey during class	Annually, 1-2 hours	H-GAC, EAMD, FWSD, HCPCT2, TBH
OSSF	Educational Information	Community members	Publication	Distributed (mail, handouts, online)	Survey	Ongoing	H-GAC, FWSD, HCPCT2, TBH
General	Public Meetings	Watershed residents	Public meeting	In person, with materials	Survey for meeting	Spring/Summer 2010	All stakeholders as possible
General	Community Survey	Watershed residents	Survey	Phone, materials, in person	N.A.	Summer 2010	H-GAC, (potentially) TBH, other stakeholders as feasible.
Trash	Educational Information	Watershed residents	Publications, meetings	Through community	N.A.	Fall 2010	H-GAC, HCPCT2
Trash	Trash Reduction	N.A.	Trash reduction event	N.A.	N.A.	At least once in 2010 or 2011	H-GAC, HCPCT2 (as grant funding allows)

8.0 IMPLEMENTATION STRATEGY DESIGN

This section is the action plan for implementing the Westfield Estates WPP. It incorporates all of the information presented in the previous sections and outlines the implementation component of the WPP. There are two basic types of management strategies to reduce bacterial water quality issues proposed: structural management strategies and non-structural/behavioral management strategies.

Prioritization in the implementation plan is based on technical feasibility, likelihood of achieving load reductions, correlation with identified stakeholder concerns, available funding and stakeholder initiatives. Based on the support of local stakeholders, including elected officials, implementation of selected BMPs and other mitigation actions will proceed according to this implementation plan. EPA's nine elements of a WPP were utilized to develop management strategies for the bacterial water quality issues identified in this Plan. An overview of these elements is included in Section 1.

The following subsections detail the various facets of the implementation plan.

8.1 Management Strategies- Overview

HCPCT2 completed a study identifying construction options for addressing bacterial contamination from humans in the Watershed. Field reconnaissance in the FSSI – Phase I showed a mix of residences with no OSSF, systems well past their useful life expectance, broken systems, improperly maintained systems, incorrectly designed systems, and some properly functioning systems.

As discussed in Section 7, a targeted survey of OSSFs on the ground in the Watershed will be conducted to identify the status of existing systems. This survey would allow for a rough cost estimate of what solutions for specific systems would be required, and what additional BMPs are needed.

All options will require proper maintenance to continue implementation load reduction. Additional water conservation measures in the form of low-flush toilets, showerheads and the like would reduce wastewater flow to the OSSFs to decrease the frequency of pump-out. Environmental justice issues may also apply in all implementation options, based on the economic status of the Community. However, the focus of efforts aimed at human bacteria reduction, in consideration of the ultimate goal of sanitary sewer installation, will be to achieve the greatest bacteria reduction possible.

Prioritization for removal and replacement, maintenance, or other means of addressing malfunctioning OSSFs will occur based on established criteria. Eligibility for these solutions will be determined based the feasibility of the site and other criteria established by the SAG.

A variety of mitigation actions were proposed to address current and future bacterial contamination and water quality threats. The implementation plan focuses on interim solutions to bacterial water quality issues in the Watershed, recognizing that the permanent solution will be to provide municipal wastewater treatment for all residents in the Watershed.

This ultimate solution to bacteria of human origin comes with a high price tag -- approximately $16 million at last estimate. Based on original stakeholder studies and input, this amount of funding is not likely within the next 15-20 years. However, recent studies and efforts by the EAMD and FWSD have indicated that sanitary sewer capacity may be obtained in the near future and that a collection system, while still an ultimate solution, may be available in a shorter time frame. At the time of this Plan's writing, the timelines and costs of this possibility are still being quantified. The timing of a sanitary sewer system may impact the ratio of structural and non-structural BMPs employed under this Plan. An accelerated sanitary sewer solution would likely reduce the need for as large an intervention in OSSF remediation in the interim, and focus more on behavioral measures and installation of low flow devices. However, until these options are fully considered and funding sources are developed, interim solutions are a viable course of action. The PAC will work towards maintaining BMPs implemented in this Plan and securing funding in the future.

Additional BMPs as discussed in Section 7 will be developed in conjunction with stakeholders, and establish public outreach and education efforts, potential OSSF regulatory reform, continuance of the SAG, and efforts to address behaviors concerning pet waste and OSSF maintenance. Success will be measured by comparing the pre-construction load of bacteria to post-implementation bacteria load in the Watershed.

8.2 Activities, Roles and Responsibilities, Indicators to Measure Progress, and Measures of Success

8.2.1 Administration of Plan Implementation

H-GAC's role, as administrator of the implementation phase of the Plan, is to effectively coordinate all Plan activities, monitor all technical and financial activities, manage files and data, serve as a liaison with the TCEQ and other local and state agencies, manage grants and other funding sources for the Plan, and coordinate the efforts of the stakeholders.

The TCEQ's role in the Plan's administration will be to help guide the implementation phase by coordinating with H-GAC, especially in the administration of the current 319(h) grant funding or future state funding sources. H-GAC will maintain regular contact with TCEQ staff throughout the implementation of the Plan, including the submission of progress reports for grants and notification of Plan activities.

Measures of Success

The measures of success will be the establishment and maintenance of clear and effective lines of communication with all participants, including TCEQ or other state personnel, and the successful coordination of the activities of implementation prior to its succession by the PSG.

The ultimate measure of success will be the ability of H-GAC to successfully guide the Plan through its implementation phase.

Indicators to Measure Progress
Metrics of these measures will include H-GAC's ability to produce regular updates on Plan implementation status for the stakeholders, the ability to coordinate activities such that they meet schedules and deadlines set forth in the Plan, and the ability to manage successfully the funding sources for the implementation of the Plan.

8.2.2 Stakeholder Advisory Groups

The SAG is an integral part of successful completion of the Westfield Estates WPP implementation. The SAG will determine guidelines for stakeholder involvement, roles, and responsibilities. Utilizing the existing partner network, which includes local officials, county government, state and federal government, special interest groups, environmental groups, developers, and citizens, the SAG will provide advice on WPP updates, QAPP amendments, and scope of work, implementation phase, and community education.

This group will also work toward watershed-wide acceptance of the Plan, promote continuing education, support maintenance programs and BMPs, and develop the long-term sustainability of the WPP. The SAG will establish how meetings, including Town Meetings, will be conducted and their frequency.

The SAG meetings will be held on a regular basis to disseminate information, provide status of work progress to the group and obtain input on next steps. Stakeholders will review and approve the WPP prior to finalization. SAG meetings will be held on a quarterly basis during the first year of implementation and thereafter as warranted by developments in the implementation of the Plan (at least twice a year until the H-GAC is succeeded by the PSG).

The Plan is best served by continuing the development of a balanced and diversified stakeholder group with an eye towards the eventual successor group. Additional participants will be recruited utilizing the existing partner network, which includes local officials, county government, state and federal government, special interest groups, environmental groups, developers, and citizens. The PAC will assume the leadership role in managing the WPP at the conclusion of the implementation.

Measure of Success
Success for this task will be marked by the continued activity of an active SAG where information is disseminated, dialogue, and discussion of issues occurs, and feedback is received to and from the Community.

Indicators to Measure Progress
The following are indicators of SAG activity and success.

- Stakeholder group participation in Plan implementation activities
- Additions to SAG membership or volunteer pools
- Official acceptance letter(s) from the Stakeholder Group approving the WPP.
- SAG participation in developing and disseminating education and outreach materials

- SAG participation at local and regional meetings to communicate the status of , and obtain input on, the Plan implementation

8.2.3 Determining Specific Management Measures

The goal of this aspect of the Plan is to identify and quantify the need for correction of specific malfunctioning OSSFs and nonhuman bacteria water quality issues sources through home surveys, characterization and prioritization of needs, qualification of homes for assistance.

Up to 500 homes in the Watershed will be evaluated for status of water use and OSSF issues. Based on this initial survey, in-depth inspection and rehabilitation plans will be developed for those homes in the Community that the stakeholders designate as suitable sites for a targeted OSSF remediation program, in conjunction with low-flow device installation. .

Criteria will be developed for prioritization of homes in need of corrective action and completing ranking process in accordance with existing Harris County practices and procedures. Homeowners will be qualified for grant assistance (full or in part) based on need.

Intake forms will include information on resident qualification and the OSSF, along with agreements for maintenance via agreement with the FWSD (required for receipt of corrective action implementation) and a requirement to connect to public sanitary system if one becomes available.

During this aspect of the Plan's implementation, vendors for low-flow devices will be secured, and potential pre-approval for residential installation will be made. Devices will be installed, with homeowner approval, as part of an initial inspection, to include preliminary review of the home's OSSF.

In addition to the structural measures put in place to remediate OSSF inputs, behavioral measures will also be devised (and revised as necessary). Educational material and other information will be disseminated to participants. Educational meetings will be held on a variety of related topics. Following collection and review of applications a priority action list will be developed. More detail on the development of these management strategies and specific activities related to them are found in Section 7 of this document.

Measure of Success

Measures of success in this task will include completion of the needs survey, initial inspections, specific site implementation plans, behavioral program measure development, prioritization, qualification, and analysis.

Indicators to Measure Progress

The following indicators are milestones in the development of management measures.

- Determining inspection criteria for homes
- Creating in-depth inspection and rehabilitation plan for homes
- Developing criteria for prioritization and qualification
- Prioritization of structural implementation
- Development of a suite of targeted behavioral measures with stakeholders

8.2.4 Implementation of Structural Corrective Measures

These measures will decrease bacterial water quality issues in the Watershed, which in turn affect Halls Bayou. Structural corrective measures will be determined on a case by case basis according to the design plan. Measures may be directed at maintenance issues such as pump-out and implementing a maintenance program for qualifying systems.

Construction components may include remediation, replacement, or installation of OSSFs according to rehabilitation plan, priority, and applicant qualification for homes. Homeowner's education will follow to ensure recipients of repairs or constructed systems follow BMPs for OSSF use and participate in maintenance agreement program. Other structural elements such as installation of low-flow devices to reduce flow to OSSFs and clearing of accumulated trash or sediment will also be utilized as needed. To address nonhuman wastes, a pilot Animal Waste Reduction Program will be implemented to provide pet waste stations, pet waste supplies, waste composting facilities or supplies, or other incentives for residential pet/domestic animal owners.

Measures of Success

The measure of success of this implementation component includes the number of malfunctioning OSSFs returned to useful service or replaced, with participation in a maintenance program, the decrease in the amount of pooled water in ditches, the decrease in the number of OSSF violations, installation of low-flow devices, reduction/removal of trash and sediment in the linear ditches, and the decrease in the level of bacteria in the Watershed. For nonhuman sources, the measures of success will be the number of animal waste facilities created or number of residents who participate in the animal waste program(s).

Indicators to Measure Progress

The following indicators will be used to gauge the progress toward implementing structural control measures:

- Structural corrective measures implemented
- Corrective maintenance plans
- Construction design of the OSSFs
- Low flow devices installed
- Maintenance Program plan and agreement form for the homeowner
- Animal Waste Reduction Program elements chosen by stakeholders/residents
- Animal Waste Reduction Program supply or construction projects implemented.

8.2.5 Implementation of Behavioral Measures through BMPs

The goal of this activity is to reduce bacterial contamination resulting from nonhuman bacterial sources through adoption of watershed BMPs. BMPs will be developed with Community involvement for human and nonhuman sources (dogs, chickens, and other determined sources) contributing to bacterial water quality issues of the Watershed.

Information, education and participation components will be particularly important here. Programs on OSSF care and maintenance will be provided at the community center. Behavioral

modification BMPs for other Community activities contributing to nonhuman source contributions to bacteria levels, particularly dogs and chickens will be addressed.

Measure of Success
Success of this WPP objective will be based on written BMPs, publication and distribution of brochures, and holding public meetings. Success will be measured by participation in educational meetings and events, and/or noticeable shifts in behavior (e.g. pet waste disposal).

Indicators to Measure Progress
Indicators include the

- Successful distribution of education and outreach materials
- Outreach and educational meetings and activities held for Community
- Observable changes in pet restraint/waste reduction practices in Westfield Estates.
- Trends indicated by a comparison of before and after surveys

8.2.6 Watershed Protection Plan Update

Updates will be based on information collected under this project, including stakeholder-based input, progress made, and any changes deemed necessary through the utilization of adaptive management principles. Finalizing the long-term successor to the SAG, which will take responsibility for maintaining the WPP, will not officially occur until the project wrap-up meeting.

Measure of Success
The Plan is updated as new information or stakeholder input is received, new progress is made, or changes are deemed necessary.

Indicators to Measure Progress
As updates are completed on an as-needed basis, there are no set indicators. However, updates should be expected to occur after major milestones (potentially including pre-and post-implementation sampling events, management measure implementation, etc). The existence of changes after these milestones, as well as the existence of other updates, will be considered indicators of progress.

8.2.7 Post-Implementation Plan

Several techniques will be used to assess the success of this project and to determine the effectiveness of remediation of a significant number of malfunctioning OSSFs to reduce bacterial water quality issues in the Watershed and ultimately the adjacent bayou:

- Post-implementation **Monitoring** - Monitor selected sites in the Community and Halls Bayou for levels of bacteria and source of contamination in accordance with sites and protocols used pre-construction
- **Survey Septic Violations** - Determine level of OSSF failure violations in Community pre- and post-implementation.
- **Quantify Water Quality Issue Reduction**- Determine decrease of bacterial sources and levels in the Watershed,

- **Continuing Maintenance**- Maintenance of OSSFs through arrangement with partner FWSD and monitored by stakeholder's group.
- **Ambient Sampling** - Monitor two sites in Halls Bayou (upstream and downstream of the Community) on a quarterly basis.

Measure of Success
Measurements of success will be collection and review of sampling data to assess success of implemented management measures on reducing bacterial levels in the Watershed.

Indicators to Measure Progress
Indicators of progress will be the successful completion of each of the evaluative techniques described above.

8.3 Schedule of Activities

The implementation schedule is divided into two segments, short and mid-term (1-4 years) in Table 13 and long term (5-10 years) in Table 14. The schedule is divided into increments that you can reasonably track and review, such as quarters or other major milestones. For a detailed review of how these implementation activities relate to the nine key elements of a WPP, please refer to Table 1.

Table 13: Schedule for Implementation Years 1-4

Action	Time
SAG meetings	At least quarterly throughout implementation
Pre-implementation sampling in ditches	Fall 2010
Community survey and reporting	Summer-Fall 2010
Town meeting on Westfield Estates WWP	Fall 2010
Final approval of Westfield Estates WPP	Fall 2010
Process development and qualification for OSSF repair, Funding/low flow installation	Summer-Winter 2010
Town meetings	Fall 2010 and at least twice a year after that
Community education and training	Fall 2010 and throughout rest of the WPP
Identify contractors and costs for repairs	Summer--Fall 2010
Begin development of Permanent Community Advisory Action Group	Summer 2010 and throughout rest of project
Prioritize order of repairs	Summer--Winter2010
Repairs/low llow installation	Fall 2010 – Summer2011
Post-implementation bacteria sampling	Summer 2011
Final report on phase II implementation	August 2011

Table 14: Schedule of Implementation Years 5-10

Action	Time
PAC Meeting	Twice per year
Ambient water quality analysis	Quarterly
Town meetings	Annual
Search for additional sources of funding	Continual basis

8.4 Interim Milestones

Interim milestones are useful to determine whether management practices or other control actions are being implemented. Milestones will be written in time intervals categorized as short-term (1 to 1.5 years), midterm (1 to 4 years), and long-term (5 to 10 years or longer).

Short term goals include assessment of the condition of individual OSSFs in the Community, installation of low flow devices, education and outreach efforts, and design plans and correction of a limited number of malfunctioning OSSFs. The short term milestones for Westfield Estates WPP are:

- Complete watershed water analysis for bacteria pre-construction
- Initiate educational/outreach programs
- Assess the condition of individual OSSF in the Community
- Design plans for implementation
- Target correction of malfunctioning or inadequate OSSFs
- Install low flow devices
- Conduct post-implementation bacterial sampling
- Select elements for an Animal Waste Reduction Program by stakeholders
- Implement of Animal Waste Reduction Program element(s)
- Transfer SAG duties to the PSG

Mid-term goals include completing the rest of OSSF remediation or installation, as funding allows, continuation of education and outreach efforts, and continuing installation of low flow devices if necessary after completion of Phase II of the WPP. Mid-term milestones are:

- Design a sanitary collection system
- Secure funding for completion of the rest of the OSSF
- Complete the rest of the OSSF remediation or installation, as funding allows and need dictates,
- Complete bacterial analysis and source identification if necessary
- Continue Animal Waste Reduction Program
- Continue education/outreach programs through the PSG

Long term goals include finding financing to complete a permanent wastewater facility for the Community. Long-term goals include:

- Secure financing to complete a permanent wastewater facility for the Community
- Continue monitoring of bacteria levels and ambient water quality above and below Watershed outfalls into Halls Bayou under the CRP program
- Continue behavioral BMPs in the Community

Table 15: Term-based Schedule for Implementation

Interim Milestones		
Short-Term	Mid-Term	Long-Term
• Complete water analysis for bacteria pre-construction • Assess the condition of individual OSSFs in the Community • Design plans for implementation • EAMD/FWSD secure capacity at WWTP • Implement OSSF education program • Implement pet waste education program • Implement domestic animal education program • Implement pet/domestic Animal Waste Reduction Program • Complete trash education and removal event • Complete public meetings (several events throughout project) • Correction of malfunctioning or inadequate OSSFs • Post-implementation bacterial sampling • Transferring SAG duties to the PSG	• Secure funding for completion of the rest of the OSSF • Complete the rest of the OSSF remediation or installation, as funding allows and need dictates • Complete necessary feasibility and design studies for permanent sanitary sewer • Continue animal waste reduction program structural elements • Address additional bacterial source identification analysis, only if necessary • Continue of behavioral education programs by PSG (pet waste, OSSF, domestic animal waste, etc)	• Secure financing to complete a permanent wastewater facility for the Community • Complete installation and hook-up of sanitary sewer collection system • Continue monitoring of bacteria levels and ambient water quality above and below Watershed outfalls into Halls Bayou under the CRP program • Continue of behavioral education programs by PSG (pet waste, OSSF, domestic animal waste, etc)

More information of specific tasks is located in Appendix AD.1 Scope of Work.

8.5 Estimation of Costs and Technical Assistance Needed

The total budget for Phase II of the Westfield Estates WPP implementation is $1,200,000, with funding through EPA's 319(h) grant program. EPA will contribute sixty percent (60%) of the funds and local partners forty percent (40%). H-GAC, or a successor agency after 2011, will manage the project with assistance from several major partners in addition to Community residents. It is possible that additional funds will be required to address all the structural problems related to bacterial water quality issues. H-GAC and its partners will attempt to secure additional funding if match is available.

8.5.1 Partners

There are eight major stakeholders/partners contributing a total of $460,000 to this project:

EAMD has pledged $60,000 towards the installation of low-flow devices and remediation of OSSFs, including contracting, managing installation/construction or repair, and assisting in the development of maintenance agreements. EAMD and FWSD will also be spending an as of yet unspecified amount on future feasibility/PER/Final Design studies and an Inter-local agreement regarding sanitary sewer capacity and, ultimately, a collection system for the Watershed.

HCPID will conduct the initial inspection of Westfield Estates homes properties for water and wastewater issues, develop rehabilitation plans for OSSFs the stakeholders designate as suitable sites under a targeted OSSF remediation program, qualify homes for grants in this program, and mail notification of inspections. This activity produces in kind match of $110,000.

GBEP will support water quality analysis and source identification or the needs survey, stakeholder group formation and support with a $100,000 commitment.

HCPCT2 through Commissioner Garcia's Office will support public education and stakeholder's meetings through in-kind contributions totaling $10,000 for meeting space, publication of meeting notices for community outreach, Spanish translation of materials, and presentations.

FWSD has committed $2,000 towards public education, mail outs to residents, stakeholder organization in the community, and development of the maintenance agreement. FWSD will also be contributing unspecified funds toward sanitary sewer development, as per the EAMD entry above.

TAMUG will support nonhuman bacteria/pathogen source identification.

H-GAC will contribute ambient water quality analysis valued at approximately $10,000.

TBH will provide volunteers and outreach support for events and publicity. As TBH is a newly added participant, the extent and value of their contributions has not yet been quantified, but will be included in subsequent updates to the Plan. TBH is an environmentally-oriented Latino

outreach group who will be helping H-GAC design and implement an effective outreach program for the Latino community in the Watershed.

The project began in June, 2009 following the conclusion of contract negotiations and concluding in August 2011. Budget details are found in Appendix D – Westfield Estates WPP Implementation Budget.

It is anticipated that this funding will address approximately fifty percent (50%) of the community needs. Additional funding ($500,000) will be sought through private foundations and/or another 319(h) grant in FY10, GLO, TWDB, or USDA grant to complete the project.

8.5.2 Budget Considerations

It is possible that the number of OSSFs requiring attention may exceed funds available under this 319(h) grant. SAG proposes to apply for additional funding to complete work if the need arises.

Cost for the maintenance of OSSFs installed under this implementation plan will be borne by the owners through a maintenance agreement with the FWSD at a fee of approximately $10-$20 per month. The FWSD will provide annual maintenance service for the systems through the estimated 20 year life of the system. Additional funding to fulfill in-kind contribution levels will need to be secured to meet current Plan goals of remediating 175 OSSFs. The need for the funding will be subject in part to the timelines currently being developed for permanent sanitary sewer.

The technical and financial needs for addressing the nonhuman sources of bacterial fall into two primary categories: educational needs and testing refinement. The primary focus in this phase of the WPP will be to begin to address domestic pet/animal waste through education efforts. Outside of some printing costs, these programs will essentially be folded into the greater educational/outreach efforts as detailed previously. The primary cost will be staff time. As the stakeholders refine the Plan, additional BMPs may be selected as funding is available. Additional testing costs may be incurred to refine the source tracking results. Some funding is already in place for these efforts, if necessary.

8.6 Information/Education Component

Development of an information/education component is necessary to enhance public understanding of the project and encourage their early and continued participation in the WPP, especially BMPs. Information, education, and public meetings will be bilingual (English/Spanish) whenever possible. Recommendations for the WPP implementation include:

- Establish a broadened stakeholders group
- Implement site-specific BMPs
- Achieve Watershed OSSF management
- Pursue funding sources for interim and permanent solutions
- Complete bacterial contamination source identification

- Quantify human health risk

Preliminary descriptions of education and outreach efforts are included elsewhere in the Westfield Estates WPP. These efforts will be expanded as the project moves forward to incorporate specific maintenance aspects necessary for long term success. Project promotion and education programs, bilingual in nature where possible, may include manned tables at local businesses (e.g. grocery store), elementary school programs, faith-based organizations, water bills inserts, fliers, residents going door to door, and town meetings.

Education on OSSF maintenance and failure prevention will be a key component. This may include OSSF brochures, with classes at a local community center. Additional detailed information is found in earlier sections of this report.

The Westfield Estates WPP is included on H-GAC's WPP web site. The Westfield Estates WPP web page includes or will include maps, the Phase I report, meeting agendas and minutes, survey forms, and status updates. The web page is located at www.h-gac.com/westfield.

The Westfield Estates WPP will be updated on a regular basis to include information collected under this project. Finalizing the PAC, which will take responsibility for maintaining the WPP, will occur at the project "Wrap-Up" meeting following the completion of the implementation phase.

Measure of Success
The measure of success of this WPP component will be the development of educational material, public participation in town meetings and continuing education classes, inclusion of Halls Bayou WPP in H-GAC's website, and completion of regular updates of the Westfield Estates WPP.

Indicators to Measure Progress
Education and public outreach activities will be included in the quarterly report. The following will be submitted with quarterly reports if listed activity occurs within a particular quarter.

- Education and outreach materials
- Webpage updates

Additionally, surveys of resident opinions and knowledge will be administered prior and subsequent to implementation of management measures. Trends identified in the evaluation of the two survey groups will help indicate progress toward goals.

8.7 Monitoring Component

8.7.1 Bacteria Monitoring and Source Identification, and Determination of Effectiveness of Implementation

There are two goals under the monitoring component of this Plan:

- To further quantify pre-implementation indicator bacteria levels; and

- To assess effectiveness of implementation practices post-implementation.

These two phases of sampling will assist in demonstrating the effectiveness of the management measures prescribed in this Plan. The two primary categories of BMPs are physical (OSSF remediation, low-flow installation) and behavioral (pet waste, trash and OSSF maintenance education).

The physical measures will be measured by observed reduction of bacterial loading. However, as discussed previously, reduction in flows from malfunctioning OSSFs to ditches may lead to an inability to sample in dry weather (i.e. if OSSF is often the primary source of standing water in the ditches). To supplement the bacterial sampling, a comparison of standing water locations in dry weather conditions will be conducted for comparison against previous field reconnaissance visits. As OSSFs are the primary contributors to standing water in the ditches during dry weather, a decrease of standing water locations may generally correlate with OSSF remediation success. These secondary effectiveness criteria will also be used as an indicator of the success of low-flow device installation. This will be backed up by projected OSSF flow reductions based on average water use savings associated with the devices.

The effectiveness of the behavioral measures, while more indirect, will be evaluated in a variety of ways. The final suite of evaluative tools will be determined by input from stakeholders and availability of data, but potential analysis could be provided through observed behavior reported on surveys, records of new, post-implementation OSSF violations, participation in outreach activities, and actual observed bacteria level changes.

In order to assure reliability of the collection, analysis, and reporting of information collected under this project, H-GAC will develop a Quality Assurance Project Plan (QAPP). The QAPP will be developed as an amendment to the Phase I QAPP that was previously approved by TCEQ. The previous QAPP was approved by stakeholders and the TCEQ, and the amended or new QAPP for the current phase will adhere to the TCEQ's Nonpoint Source Program 319(h) shell.
The purpose of data collected under this QAPP is to establish pre- and post implementation levels of bacteria. Data will not be submitted to the TCEQ's Surface Water Quality Monitoring Information System (SWQMIS) but will be available to TCEQ and other programs as data collected under an approved QAPP.

Two sampling phases pre-implementation (FY10) and post implementation (FY11) are planned and interim sampling may occur if the need arises. Sampling sites and periods will correspond to those used in Westfield Estates WPP Phase I. This protocol will enhance baseline data and provide comparative pre- and post-project data at a site that has had previous detections of indicator bacteria. The data will be used to characterize the indicator bacteria levels and to determine the impact of multiple BMPs over time at the watershed scale for the Westfield Estates WPP. The current plan for post-implementation monitoring would include BST to determine changes in the relative ratio of sources. However, the need for this additional BST work may be dependent on the state of the technology at that time, availability of data from other efforts in the area, and input from stakeholders. Due to the general lack of confidence in the precision of these technologies, the Plan currently aims to utilize BST to compare known rather

than further investigate the 34% of unknown. This may be undertaken in subsequent efforts, but the primary concern is with the known sources, especially the OSSFs. Please see Section 3 in this Plan for more detailed information.

H-GAC monitors two CRP sites immediately upstream and downstream of the Watershed inflow in Halls Bayou. The ambient water quality data collected as part of the CRP falls under the QAPP for that program. Since improvement in the water quality issues post-project may take up to two years to become evident, monitoring through the CRP program after the conclusion of the project is essential. A summary of the CRP results will be provided with annual reports throughout the course of the study.

Because this information may have applicability to the Houston Metro TMDL, which includes Halls Bayou, the Watershed QAPP will be submitted to the TCEQ-TMDL Team for QAPP approval.

H-GAC will submit the data to TCEQ at the conclusion of each sampling phase in a quarterly report following 60 days after completion of the report. Ambient data is collected quarterly under the CRP program will be submitted on an annual basis.

Measure of Success
The success of this task will be measured by receipt of approval for the QAPP, approved amendments as needed and continuing conformance to QAPP provisions. Annual updates will be provided to TCEQ.

Indicators to Measure Progress
The following will be submitted with quarterly reports if listed activity occurs within a particular quarter.

- QAPP update and input (annually) – 30 days prior to end of the fiscal year
- Water quality data submittal (CRP) – annual

Water quality monitoring non-conformances will be included in quarterly progress reports.

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APPENDICES

Appendix A - Public Awareness and Education Activities

Table A.1 – Summary of Public Meetings and Outreach 2006 -2007

2006	Location	Activity Type	No. of Persons	Primary Topics	List of Organizations
March 9	H-GAC Office	Discuss FSSI partnership with 4 HCPCT 2	4	Draft report HCPCT 2 needs for sewer service and FSSI opportunities	Commissioner Garcia's Staff, CDM (Consulting), H-GAC
May 5	Com. Sylvia Garcia's Office	Present proposal for FSSI partnership	7	FSSI opportunities for partnership	HCPCT 2 staff, H-GAC
June 9	Westfield Estates	Field Reconnaissance	6	Concerns for black water in Community ditches	H-GAC, Community Residents
July 7	Westfield Estates	Field Reconnaissance	7	Concerns for black water in Community ditches	H-GAC, Community Residents
August 17	GBEP Offices	GBEP – WQS Subcommittee	10	Project up-date and status	GBEP, H-GAC, TCEQ, City of Pasadena, Texas Sea Grant & Texas Cooperative Extension; Gulf Coast Waste Authority
August 30	Westfield Estates	Field Reconnaissance	9	Concerns for black water in Community ditches	H-GAC, Community Residents
September 18	Westfield Estates	Outreach During Sampling	10	Concerns for black water in Community ditches	H-GAC, Hygeia Laboratories, TAMUG, Residents
September 26	Westfield Estates	Outreach During Sampling	11	Concerns for black water in Community ditches	H-GAC, Hygeia Laboratories, TAMUG, Residents
November 28	Westfield Estates	Outreach During Sampling	5	Concerns for black water in Community ditches	H-GAC, Hygeia Laboratories, Residents

2007	Location	Activity Type	No. of Persons	Primary Topics	List of Organizations
January 8	FWSD Admin. Building	Board of Director's Meeting	11	Water quality monitoring results, locations, density of OSSFs, risk assessment and correction strategy. Inclusion of OSSF Care brochure with water bills.	FWSD Board of Directors, Private citizens, Engineer, Operator, FWSD Attorney.
January 17	Northeast Community Center	Town Meeting	N/A	Water quality monitoring results, locations, density of OSSFs, risk assessment and correction strategy.	Meeting cancelled because of inclement weather. See February 13 Meeting Information
January 24	GBEP – State of the Bay Symposium	Regional Stakeholder Biennial Symposium	55	Water quality monitoring results, locations, density of OSSFs, risk assessment and correction strategy.	Galveston Bay Estuary Stakeholders in the Region, TCEQ TMDL Section
February 1	H-GAC Office	NRAC Quarterly Meeting	45	Final FSSI Report including water quality monitoring results, locations, density of OSSFs, risk assessment and correction strategy.	County Representatives: Harris, Brazoria, Galveston, Montgomery, Walker, and Liberty; Quest Engineering, San Jacinto River Authority, GBEP, HCFCD, Kingwood College, Gulf Coast Waste Disposal, Upper Kirby District, Dannenbaum Engineering, Reliant Energy, Galveston Bay Foundation, Friends of San Bernard River.

2007	Location	Activity Type	No. of Persons	Primary Topics	List of Organizations
February 9	H-GAC Office	Discuss FSSI partnership with 4 HCPCT 2	4	Draft report HCPCT 2 needs for sewer service and FSSI opportunities	Commissioner Garcia's Staff, CDM (Consulting), H-GAC
February 13	Com. Sylvia Garcia's Office	Present proposal for FSSI partnership	7	FSSI opportunities for partnership	HCPCT 2 staff, H-GAC
February 15	Westfield Estates	Field Reconnaissance	6	Concerns for black water in Community ditches	H-GAC, Community Residents
February 16	Westfield Estates	Field Reconnaissance	7	Concerns for black water in Community ditches	H-GAC, Community Residents

2008	Location	Activity Type	No. of Persons	Primary Topics	List of Organizations
November 14	H-GAC Offices	SAG Meeting	8	Discuss and approve Sections 1-5 of WPP, Stakeholder summary, plan outline and other documents	SAG members and interested parties; Meeting agenda and notes available online at www.h-gac.com/westfield
December 15	H-GAC Offices	SAG Meeting	6	Discuss and approve SOW, QAPP, sections 6-8 of the WPP, contract negotiation	HCPCT 2 staff, H-GAC

See appendix E in FSSI report for CD inclusions

Appendix B - Analytical Data

B.1 Data Sources Available

Table B.1.1 Database Resources Available for Completion of Westfield Estates WPP

Name	Source	Date	Description
ABI Businesses	Census Data	2000	GIS- Business in Harris County, includes some housing data
Land Cover	H-GAC	2002	GIS - Complete data set
Land use	H-GAC	2000	GIS - Source unknown appears to be from 2000
Hydrography	NHD	2000	GIS - newer sets available below
Hydrography	Census Bureau	1990	GIS - Older data set
Hydrography	Census Bureau	2000	GIS Shapefiles
Watershed	TCEQ	2003	GIS - from TCEQ
Coastal Preserve	GLO\USGS	2000	GIS Shapefiles
County Line	Census Bureau	1990	Forecast - Older census data
County	TXDOT	2000	GIS Shapefiles
DEM	H-GAC	2000	GIS Shapefiles
Urban Centers	Census Bureau	2000	GIS Shapefiles complete set for 2000
Roads	TXDOT	2000	GIS Shapefiles
Roads	H-GAC-Starmap	2007	GIS Shapefiles - complete and most accurate
Roads	Census Bureau	1990	GIS Shapefiles
Roads	Census Bureau	2000	GIS Shapefiles
Main Roads	TNRIS	2000	GIS Shapefiles
Continuous Monitoring System(incl. ambient)	H-GAC	2006	GIS Shapefiles - complete
Continuous Monitoring System(incl. ambient)	H-GAC	2007	GIS Shapefiles - complete and most accurate
Continuous Monitoring System(incl. ambient) (historic)	H-GAC /TCEQ	2000	GIS Shapefiles - complete
Aerial Imagery	H-GAC	2006	GIS Shapefiles - complete and most accurate
Aerial Imagery	H-GAC	2004	GIS Shapefiles - complete
Aerial Imagery	NAIP	2005	GIS Shapefiles - complete, high quality
DOQQs	H-GAC	1990	Unknown date most likely 1990
Wastewater SA	H-GAC	2007	GIS Shapefiles - complete
WWTP Outfalls	TCEQ	2007	GIS Shapefiles - complete set
Soil	NRCS	2000	GIS Shapefiles - date uncertain
Potential Septic	H-GAC	2005	incomplete data set, not comprehensive for several
System			zip codes
Lidar Elevation	FEMA	2006	Most recent
Contours	USGS	2000	GIS - Shapefiles
Congressional Dist	Census Bureau	2004	GIS - Shapefiles, errors in elected officials but not precincts, can combine with contact database for accurate precinct reps.
Flood Zones	FEMA	2000	GIS - Older data set, date unknown
Population	Census Bureau	2006	Tabular
Housing Units	HCAD	2006	Tabular - from model
Inventory of Buildings	HCAD	2006	Tabular incl. housing
Property Valuations	HCAD	2006	Tabular - protests not included

Table B.1.2: Clean Rivers Program Monitoring Parameters[35]

PARAMETER	UNITS	MATRIX	METHOD	PARAMETER CODE	AWRL	Limit of Quantitation (LOQ)	RECISION (RPD of LCS/ LCSD)	BIAS %Rec . of LCS	LOQ CHECK STANDARD %Rec	LAB
pH	pH/ units	water	EPA 150.1 and TCEQ SOP, V1	00400	NA*	NA	NA	NA	NA	Field
DO	mg/L	water	SM 4500-O G And TCEQ SOP, V1	00300	NA*	A	NA	NA	NA	Field
Conductivity	µS/cm	water	EPA 120.1 and TCEQ SOP, V1	00094	NA*	NA	NA	NA	NA	Field
Salinity (tidal sites only)	ppt, marine only	water	SM 2520 and TCEQ SOP, V1	00480	NA*	NA	NA	NA	NA	Field
Temperature	°C	water	SM 2550 B and TCEQ SOP V1	00010	NA*	NA	NA	NA	NA	Field
Secchi Depth	meters	water	TCEQ SOP V1	00078	NA*	NA	NA	NA	NA	Field
Days since last significant rainfall	days	NA	TCEQ SOP V1	72053	NA*	NA	NA	NA	NA	Field
Total water depth	meters	water	TCEQ SOP V2	82903	NA*	NA	NA	NA	NA	Field
Flow severity	1-no flow, 2-low, 3-normal, 4-flood, 5-high, 6-dry	water	TCEQ SOP V1	01351	NA*	NA	NA	NA	NA	Field
Flow, Instantaneous	cfs	water	TCEQ SOP V1	00061	NA*	NA	NA	NA	NA	Field
Flow, Daily Average	cfs	water	TCEQ SOP V1	00060	NA*	NA	NA	NA	NA	Field
Flow measurement method	1-gage 2-electric 3mechanical 4-weir/flume 5-doppler	water	TCEQ SOP V1	89835	NA*	NA	NA	NA	NA	Field
Tidal Stage (tidal sites only)	1-low 2-falling 3-slack 4-rising 5-high	NA	NA	89972	NA*	NA	NA	NA	NA	Field
Present Weather	1-clear 2-partly cloudy 3-cloudy 4-rain	NA	NA	89966	NA*	NA	NA	NA	NA	Field
Turbidity, Observed	1-low 2-medium 3-high	water	TCEQ	88842	NA*	NA	NA	NA	NA	Field
Water Clarity (if no secchi)	1-excellent 2-good 3-fair 4-poor	water	TCEQ	20424	NA*	NA	NA	NA	NA	Field
Water Color	1-brownish 2-reddish 3-greenish 4-blackish 5-clear 6-other	water	TCEQ	89969	NA*	NA	NA	NA	NA	Field

[35] TCEQ.

Water Odor	1-sewage 2-chemical 3-rotten egg 4-musky 5-fishy 6-none 7-other	water	TCEQ	89971	NA*	NA	NA	NA	NA	Field
Water Surface	1-calm 2-ripples 3-waves	water	TCEQ	89968	NA*	NA	NA	NA	NA	Field
Wind Intensity	1-calm 2-slight 3-moderate 4-strong	NA	NA	89965	NA*	NA	NA	NA	NA	Field

* Reporting to be consistent with SWQM guidance and based on measurement capability.

PARAMETER	UNITS	MATRIX	METHOD	PARAMETER CODE	AWRL	Limit of Quantitation (LOQ)	Precision (RPD of LCS/ LCSD)	BIAS %Rec. of LCS	LOQ Check Standard %Rec	Lab
Conventional and Bacteriological Parameters										
Chloride	mg/L	water	EPA 300.0 Rev.2.1 (1993)	00940	5	5	20	80-120	70-130	Braes
Sulfate	mg/L	water	EPA 300.0 Rev.2.1 (1993)	00940	5	5	20	80-120	70-130	Braes
TSS	mg/L	water	EPA 160.2	00530	4	4	20	80-120	NA	Braes
TDS, dried at 180 dC	mg/L	water	EPA 160.1	70300	10	10	20	80-120	NA	Braes
E. coli, IDEXX Colilert	MPN/ 100mL	water	SM 9223-B	31699	1	1	0.5**	NA	NA	Braes
Enterococcus, IDEXX Enterolert	MPN/ 100mL	water	ASTM D-6503	31701	1	1	0.5**	NA	NA	Braes
Fluoride	mg/L	water	EPA 300.0 Rev. 2.1 (1993)	00951	0.5	0.5	20	80-120	70-130	Braes
Ammonia-N, total	mg/L	water	EPA 350.1 Rev. 2.0 (1993)	00610	0.1	0.1	20	80-120	70-130	Braes
O-phosphate-P, field filter <15 min.	mg/L	water	EPA 365.1	00671	.04	.04	20	80-120	70-130	Braes
Total Phosphorus-P	mg/L	water	EPA 365.1	00665	.06	.06	20	80-120	70-130	Braes

B.2 Available Monitoring/Resource Data– Halls Bayou

Water quality monitoring and resource data is available for Halls Bayou from a variety of sources including local partners, H-GAC and many governmental agency databases as collected under the CRP program. Data on water quality for Halls Bayou adjacent to Westfield Estates is also available from HGAC monitoring in FSSI Phase I and more recently through the Clean Rivers Program.

Water Quality data for Halls Bayou is available from several sites: USGS (flow), City of Houston (water quality parameters, see Appendix B-Analytical Data) and H-GAC (ambient water quality parameters, including bacteria, and flow).

USGS maintains a flow monitor gauge (08076500) about one mile downstream from Westfield Estates (intersection of Jensen Drive and US Highway 59) with data beginning in the 1950's. Because of the low conveyance of the Bayou and based on H-GAC flow measurements, flow at the USGS station (adjacent to Westfield Estates) and 2 miles upstream (Airline Drive) is virtually identical. Thus, current and historical flow data is available for Halls Bayou surrounding Westfield Estates (USGS and the City of Houston) and directly adjacent to Westfield Estates (H-GAC) since 2008.

The City of Houston Health and Human Services Department monitors water quality including bacteria levels at both the USGS Jensen and Airline sites. The city began collecting fecal coliform data in 1999, but changed to *E. coli* in late 2001. Data from 2005 through 2008 has not yet been certified by TCEQ; however, it is available for use in waste load calculations. (See Section 5.0 Linkage of Pollution Loads to Water Quality)

H-GAC monitors two sites in Halls Bayou immediately upstream and immediately downstream of Westfield Estates as part of its Clean Rivers Program. Parameters include those for water quality, bacteria, and flow. H-GAC monitoring began in October 2007 in preparation for the Westfield Estates WPP implementation. For the purpose of the Westfield Estates WPP, an additional four monitoring locations in Halls Bayou adjacent to the Watershed were examined, (Phase I). Additional sampling is proposed as part of the Westfield Estates WPP implementation.

B.2.1 Flow

The principal site for monitoring flow along Halls Bayou (Station number 08076500) is located under the U.S. Hwy 59 bridge (latitude 29° 51' 42" and longitude 95° 20' 05") where it crosses the bayou. It is identified as Hydrologic Unit 12040104. This is approximately 1 mile downstream from Westfield Estates. At this point, the contributing drainage area is 28.7 square miles. Data show that median stream flow for the bayou is 9.0 ft3/second over an 11-year history (Table B.2.1). Peak stream flow data is shown in Figure B.2.1. It is evident that the flow and character of the bayou varies considerably over time with dramatic changes seen following torrential rain events. H-GAC began monitoring studies adjacent to Westfield in 2008. These studies are ongoing. Data is collected on a periodic basis during dry and wet weather conditions.

Table B.2.1: Halls Bayou Stream Flow Measurements (1997-2008)[36]

Parameter	Minimum	Median	Maximum
Stream flow (ft^3/second)	8.3	9.0	2660
Gage height	45.6	45.9	57.35*
Stream width (ft)	24	31	118
Cross section area (ft)	11.1	22.8	858
Mean velocity (ft/sec)	0.29	0.39	3.14
Mean depth		0.74	
Elevation of datum of gauge (feet above sea level NGVD29)	-	-.66	-

*Note: Flood stage is 54 feet.

[36] USGS. 2008 National Water Information System. USGS Water Data for Texas. Washington, D.C.: USGS Retrieved May 7, 2008. http://nwis.waterdata.usgs.gov/tx/nwis/peak?site_no=08076500&agency_cd=USGS&format=img

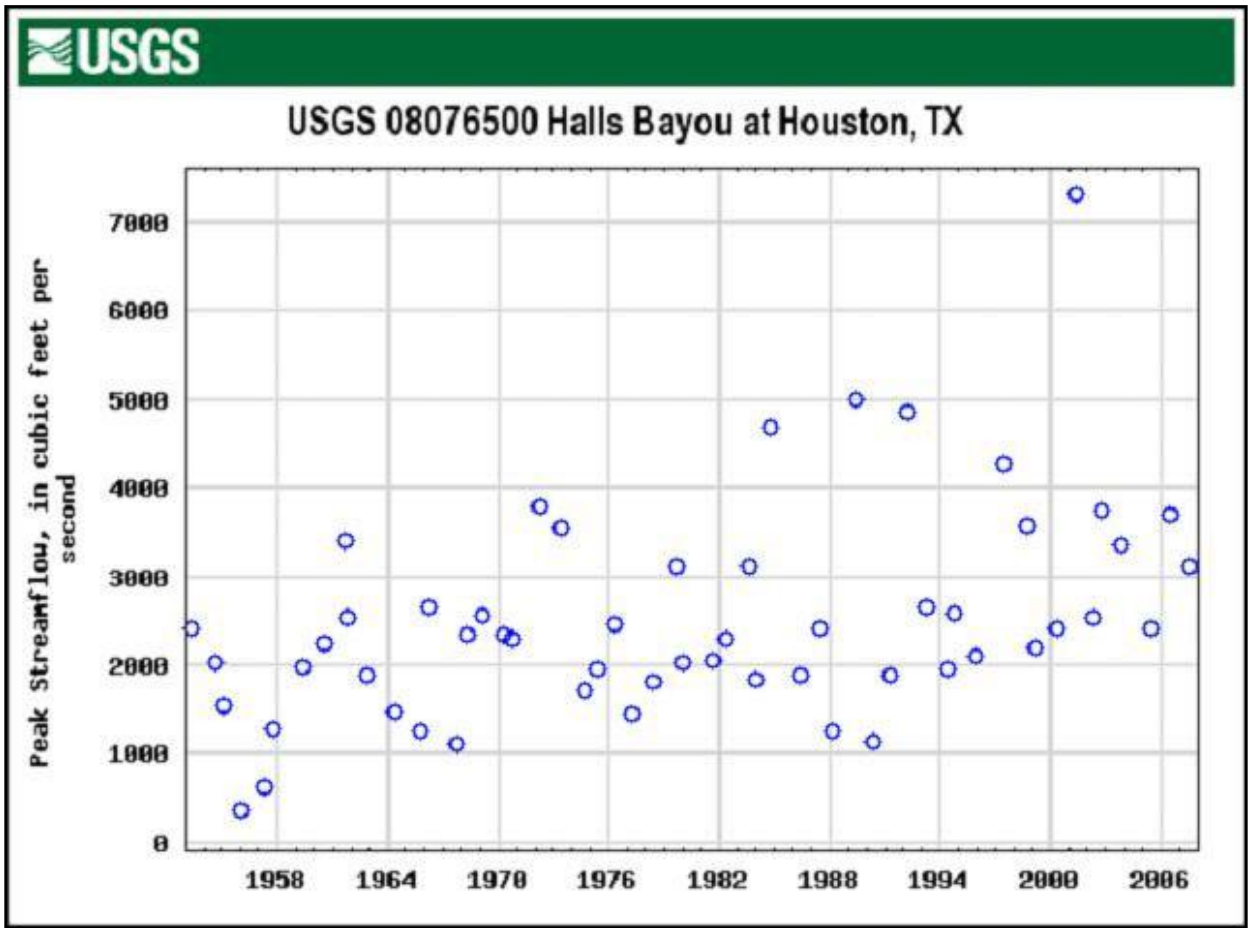

Figure B.2.1: Peak Stream Flow for Halls Bayou at U.S. 59, 1952-2008[37]

[37] IBID.

Table B.2.2: Significant Area Floods Along Halls Bayou[38],[39],[40]

Year	Date	Description
1935	December 6-8	20.6" in 35 hours over Westfield, TX
1972	March 20	7.47" rain at IAH airport, 7.01" in 3 hours; Independent Heights 7.65" Halls Bayou 9.5"
1987		5 to 10 inches of rain fell across the area. One fatality (drowning) occurred on the Halls Bayou.
1989	June 25July 7	The remnants of TS Allison produced heavy rain and flooding
1993	Mar 1-2	Halls Bayou near Jensen over its banks and bank-full conditions on Greens Bayou. One home flooded along Greens Bayou; 2"-3" rain, 4"-5" in some scattered locations
1996	Sep 27	Street flooding NE Houston
2000	May 19	Major Flooding on Greens Road, Aldine Westfield; 1 foot of water in the approach control tower;
2001	June 6-9	Tropical Storm Allison, widespread flooding, >35" of rain
2003	November 16-17	Flooding in Aldine. 24 tornadoes touched down during 15 hour period of severe weather in southeastern Texas on November 17th. 300 homes were flooded in Harris County and hundreds of vehicles were flooded.
2005	May 29	Flooding in Aldine
2006	May 30	Up to 12 inches of rain over six hours in Eastern Harris County. Several homes along Halls Bayou flooded.
2008	Sept. 13	Flooding associated with Hurricane Ike

[38] Water Research Center. 2008. Retrieved July 30, 2008.
[39] http://www.srh.weather.gov/hgx/severe/events/june.htm
[40] USA today. 2006. "Flooding in Texas." Retrieved on July 30, 2008. from http://www.usatoday.com/weather/storms/2006-05-30-texas-flooding_x.htm .

B.2.2 Water Quality

The City of Houston has collected ambient water quality samples at several locations on Halls Bayou since 1990. Three sites are of interest for the Westfield Estates WPP. A summary of data from 2000 through 2006 is found in Table B.2.2.1. Data from 2006 until the present will be included in future updates prior to post-implementation sampling. A summary of monthly *E. coli* levels is shown in Figure B.2.2.1.

The upstream site (17490), approximately 2 miles north, northeast, is located at Airline Drive. The bayou at this point is narrower than it is at Westfield Estates, but the low flow rate is almost identical to that at Westfield Estates because of the flat landscape and thus low conveyance of the bayou in this area. A data summary for the years 200 through 2006 is found in Table B.2.2.2. Data from 2006 until the present is not yet available because it has not been certified by TCEQ. A summary of monthly *E. coli* levels is shown in Figure B.2.2.2.

An additional upstream site is located 4 miles upstream at Tidwell drive. See Figure 19 for the location of all three sites.

USGS collects limited water quality data at the City of Houston site where it maintains a flood gauge. Data collected in 1997-1998 is shown in Table B.2.2.3. Additional data will be collected an included in the final draft of the Westfield Estates WPP.

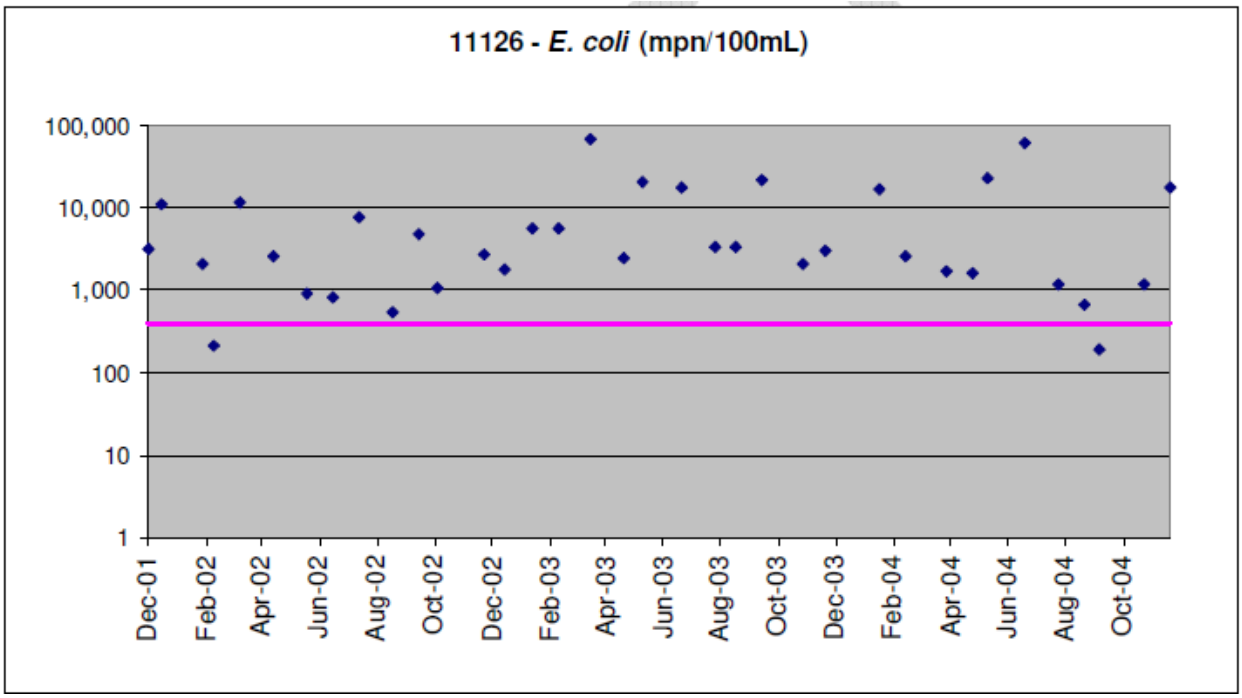

Figure B.2.2.1: Summary of *E. coli* levels – City of Houston Site 11126 (Halls Bayou at Jensen Drive) from 2001-2004

Table B.2.2.1: Summary of Water Quality Data – City of Houston Site 11126 (Halls Bayou at Jensen Drive) from 1992-2006

Station and Parameter	Start Date	End Date	Number of Samples	Number of Exceedences	Percent Exceedences	Minimum Value	Maximum Value	Mean Value	Median Value	Standard Deviation
1126 Halls Bayou at Jensen Dr.										
Field Parameters										
Temperature (Centigrade)	Nov-92	Dec-06	149	0	0%	10.7	34.4	22.8	23.2	5.93
Dissolved Oxygen (mg/L)	Nov-92	Dec-06	142	0	0%	2.3	14.0	6.9	6.9	1.97
pH (standard units)	Nov-92	Dec-06	100	0	0%	6.9	8.9	7.6	7.6	0.30
Conductivity (µmhos/cm)	Nov-92	Dec-06	121	0	0%	162	853	627	665	153.35
Bacteria										
E. coli (MPN/100mL)	Dec-01	Dec-06	61	48	79%	10	98,000	7,475	1,700	17,144.43
Nutrients										
Ammonia (mg/L)	Nov-92	Dec-06	159	97	61%	0.05	9.84	1.00	0.62	1.13

Table B.2.2.2: Summary of Water Quality Data – City of Houston Site 11126 from 2002-2006

Station and Parameter	Start Date	End Date	Number of Samples	Number of Exceedences	Percent Exceedences	Minimum Value	Maximum Value	Mean Value	Median Value	Standard Deviation
17490 Halls Bayou at Airline Dr.										
Field Parameters										
Temperature (Centigrade)	Jan-02	Dec. 06	57	0	0%	13.1	31.0	23.3	23.6	5.40
Dissolved Oxygen (mg/L)	Jan-02	Dec. 06	54	0	0%	3.5	10.1	6.4	6.5	1.53
pH (standard units)	Jan-02	Dec. 06	54	0	0%	6.8	8.3	7.5	7.6	0.26
Conductivity (µmhos/cm)	Sep-02	Dec. 06	48	0	0%	135	859	654	715	182.63
Bacteria										
E. coli (MPN/100mL)	Jan-02	Dec. 06	59	54	92%	120	110,000	12,781	3,000	24,608.73
Nutrients										
Ammonia (mg/L)	Jan-02	Dec. 06	58	44	76%	0.08	3.26	0.99	0.73	0.77
Nitrate (mg/L)	Sep-03	Dec. 06	38	4	11%	0.42	12.10	5.62	5.35	2.98
Total Phosphorus (mg/L)	Sep-03	Jan-00	39	33	85%	0.32	2.69	1.51	1.47	0.68

Table B.2.2.3: Statistical Summary of Water Quality USGS Data – 1997-98 Halls Bayou[41]
Halls Bayou at Airline Drive at Low Flow City of Houston Site 17490

Measurement	Minimum	Mean	Maximum
Water Temperature (°C)	21.4	28.6	32.0
Specific conductance (microS/cm)	749	780	829
pH	7.5	7.7	8.0
Dissolved Oxygen (mg/L)	5.0	7.3	9.0
Total Suspended Solids (mg/L)	10.0	14.2	20.8
Hardness (mg/L as $CCaCO_3$)	168	172	179
Dissolved Chloride (mg/L)	90.7	93.8	96.3
Flow (ft3/sec)	11.1	15.25	531

H-GAC has been collecting ambient water samples, including levels of bacteria, at two locations in Halls Bayou adjacent to Westfield Estates since October 2007. This data has not yet been compiled, but will be included in the final Westfield Estates WPP.

B.2.3 Biological Data and Habitat Survey

There is no recent biological data available for the Halls Bayou Watershed. The USGS under contract with H-GAC conducted biological data collection in 51 sites in the H-GAC service area in 1997-98. The closest site to Halls Bayou in that study was in Greens Bayou, for which Halls Bayou is a tributary

H-GAC does have some basic habitat data available that was collected by local CRP partner agencies. Benthic data is most often collected during special studies and intensive surveys conducted through the Clean Rivers Program or TCEQ SWQM team. H-GAC will ask its CRP Steering Committee to consider allocating funds under it next contract in FY10-11 to conduct a special study in the Halls Bayou Watershed for the collection of biological and benthic data that will help support the WPP process.

The Texas Gulf Coast, including Harris County and Westfield Estates, is located on the major Central Flyway for migratory birds. The Gulf Coast is renowned location for international bird watchers. Over 333 species are visible year round. Phase I bacterial source identification studies

[41] U.S, Department of the Interior and U.S. Geological Survey. 1999. "Estimation of Minimum 7-Day, 2-Year discharge of Selected Stream Sites, and Associated Low-Flow Water-Quality Data, Southeast Texas 1997-98." USGS Fact Sheet FS-122-99

did not examine the contribution of wild birds to bacterial contamination in the Community and the bayou.

B.3 Pollution Source and Assessment - Halls Bayou

B.3.1. Point Sources

There are five NPDES/TPDES permitted facilities that discharge to Halls Bayou Watershed within two (2) miles and upstream of the Watershed (Table B.3.1.1). The locations of these facilities are found in Figure B.3.1.1.

Table B.3.1.1: NPDES Permit Holders within 2 mile Radius of Westfield Estates[42]

Permittee	NPDES Permit Number	Type	Location	Average Flow	Renewal Date	Comments
SUNBELT FWSD - OAKWILDE WWTP	TX0021253	Domestic wastewater treatment - Municipal plant	N. of Mooney Rd & East of bayou	0.450 MGD		Within permit last 5 years. No significant *E. coli* detected in effluent in H-GAC Phase I study.
HOOKS MOBILE HOME PARK WWTP	TX007888	Domestic wastewater treatment - Private entity	12019 Aldine Westfield Rd			Not directly on Halls Bayou
CHAMP'S WATER COMPANY (Mobile home park)	TX0032093	Domestic wastewater treatment – Private entity	Immediately West of Keith Weiss Park on Halls Bayou			
GREENWOOD VILLAGE PLT	TX0032034	Domestic wastewater treatment - Private entity	3010 Kowis St East Bank of Halls Bayou			Outfall not visible from bank.
SUNDOWN MOBILE HOME PARK	TX008778	Domestic wastewater treatment - Private entity	12117 Aldine – Westfield Rd			

[42] IBID.

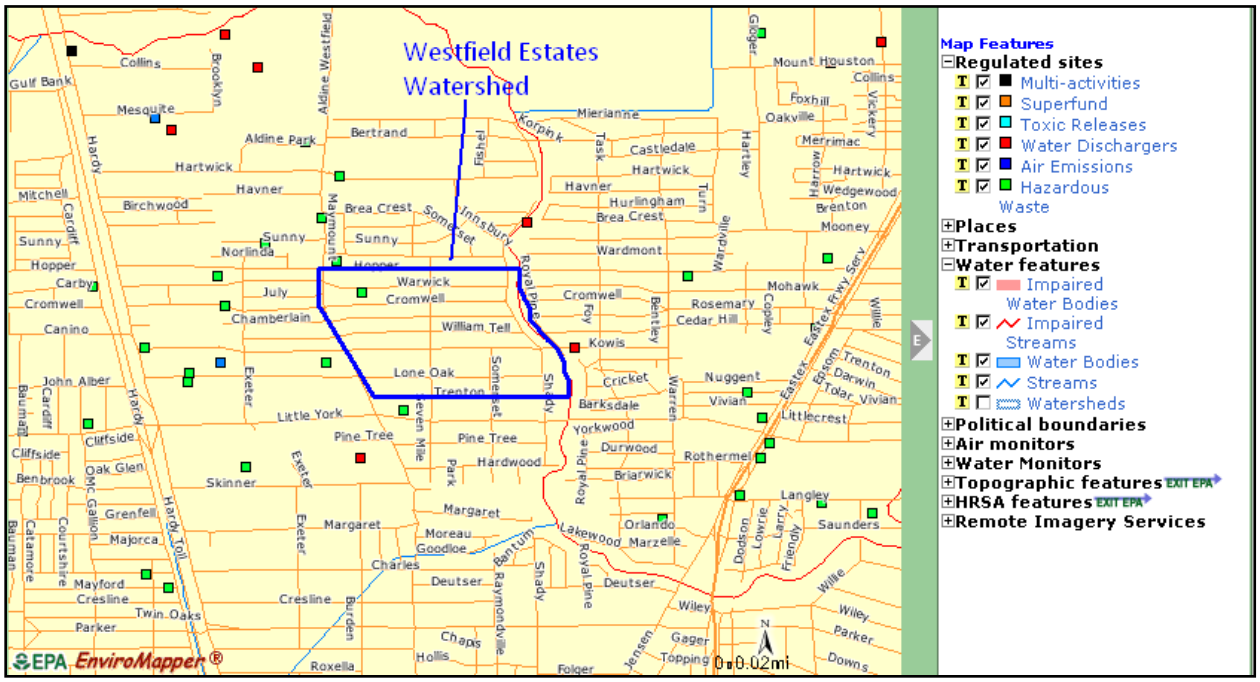

Figure B.3.1.1.: Possible Sources of Pollution in Westfield Estates Watershed
(Source: EPA Envirofacts 2009)

Bacteria

H-GAC analyzed bacterial data to provide information on the magnitude of bacterial contamination in the Community and Halls Bayou and to characterize the source of the contamination, either human or nonhuman. Determination of the connection between potential human illness and the presence of waterborne pathogens would be possible after completion of a future epidemiological study. This information is useful in the development of outreach strategy targeted towards homeowners, elected officials and developers.

Baseline water quality, as measured by levels of *E. coli*, within Halls Bayou is the subject of ambient monitoring by TCEQ. A water quality monitoring station (11126) is located approximately 1 mile downstream from the Watershed in Stream Segment 1006D (Houston Ship Channel).

Ambient water quality data for *E. coli* (MPN/100 ml) for Station 11126 on Halls Bayou were collected at 36 sampling events between December 2001 and November 2004. Of the 36 samples, 34 (or 94%) showed exceedence. The minimum value was 190 MPN/100 ml and the maximum was 69,000 MPN/100 ml. Data shows a mean value of 9,310 MPN/100 ml with a median value of 2,900 MPN/100 ml.

More recent sampling shows improvement on Halls Bayou. In 2005, 18 samples were collected at Station 11126. One event showed *E. coli* levels of 98,000 MPN/100 ml. Of the remaining 17

sampling events, the minimum value was zero and the maximum value was 5,600, with an exceedence rate of 35%. Exceedence generally occurred within 4 days of a rain event. The mean value was 213, while the median was 150 (excluding the 98,000 for statistical deviation reasons).

For nine sampling events available for 2006, levels of *E. coli* were still lower, ranging from zero to 1000, with three events exceeding State criteria for contact recreation (33%). The *E. coli* level of 1000 was recorded within 2 days of a rain event. The median for this period was 210 and the mean at 324. In the H-GAC study, 13 samples were collected between September and December 2006. *E. coli* levels ranged from zero to 1986 MPN/100 ml, with three exceedences (23%).

Complete ambient water quality data for the bayou is available at the H-GAC website www.h-gac.com.

Sampling for *E. coli* contamination in Halls Bayou was conducted on several dates (Table B.3.1). The Hopper Street Bridge is upstream of Westfield Estates. Levels of bacteria at this location should be an indication of Halls Bayou water quality prior to contact with waters from storm sewer (drainage ditch) outfalls in the Community. This location is directly downstream of the FWSD wastewater treatment plant.

The downstream location chosen is under a footbridge, south of the last Community storm water outfall, from Kowis Street. It serves as a reference point for determining total bacterial contamination coming into the Bayou from the Community.

Several storm water outfalls between these two points were also examined. It was not possible to collect samples at these locations on all of the sampling dates because of safety considerations during or shortly after rain events. The banks of Halls Bayou are very steep and grass covered at these locations and slippery when wet.

The highest concentration of *E. coli* occurred during dry weather upstream of the Community, which exceeded state standards for contact recreation at least 300-fold, with bacteria levels in excess of 100,000 MPN/100 ml. Levels of bacteria at storm water outfalls from the Community were very low in comparison.

At the first wet weather-sampling event (W1), *E. coli* levels for the upstream and downstream locations were both elevated at about three times the State standard. One of the storm water outfalls, Chamberlain Street was above this level. At this location, the conduit was partially submerged under water so a sample was taken adjacent to it from the Bayou. The other two conduits were far enough above water level in the Bayou to collect samples directly. Both locations exhibited significantly elevated levels of *E. coli* of around 100,000 MPN/ 100 ml. However, based on the downstream sample, it appears that bacterial contamination from the Community did not adversely affect water quality in Halls Bayou on this occasion. At the second wet weather sampling event, the upstream location was 20-fold lower than the downstream location.

The third wet water sampling event both upstream and downstream locations showed exceedence above state standards, with the upstream location almost twice as high as the downstream.

Clearly, because of the low number of samples taken and variability in conditions, further studies are required for conclusive results on *E. coli* bacterial contamination in this section of Halls Bayou. However, it is possible bacterial contamination from the Community, at least on these occasions, will not be as significant a contributor to overall water quality degradation as originally thought.

Table B.3.1.2: Bacterial Quantitative Assessment of *E. coli* – Halls Bayou

Address (Block)	Weather	*E. coli* (MPN CFU /dL)
Under Hopper Bridge	D (LS) W1 W2 (FS) W3	130,000 / 198,600 11,800 1700 / 1000 5200
West Side of Bayou - Cromwell Outfall	D (FS) W1	1000 / 600 98,000
West Side of Bayou - Chamberlain Outfall	W1	13,800
West Side of Bayou - William Tell Outfall	D W1	1000 141,400
West Side of Bayou - Near Kowis Outfall	D W1 W2 (LS) W3	1500 13,500 34,500 / 48,800 2900
Sewage Plant - Outfall	W1 W2	0 0

D = Dry Weather, no rain 7 days, September 26, 2006; 85◦ F
W1 = Wet Weather, ½ inches of rain preceded sampling by 1 hour on November 28, 2006**; 72** ◦ F
W2 = Wet Weather, rain preceded sampling by 1 hour on December 11, 2006, 50 ° F
W3 = Wet weather, rain during sampling, January 30, 2007; 45◦ F
LS = Laboratory Split
FS = Field Split

FWSD Outfall

Historically, persistent bacteria exceedence, especially concentrations in the range shown in this study, appears to be associated with proximity to wastewater treatment outfalls. Often human illness is associated with contact with inadequately treated wastewater from bypass, overflow, or malfunction of the treatment plant.

There have been no recorded violations at the wastewater treatment plant in the past two years. Samples taken at the wastewater treatment plant outfall showed virtually no *E. coli* or Enterococcus on two separate occasions.

Appendix C – Modeling

C.1 Westfield Estates Existing Conditions and Pollutant Load Estimates

The Watershed is a small urban watershed consisting of 8 longitudinal residential streets. While the natural drainage of the area begins at the Hardy Toll Road north-bound feeder road and would drain due east for approximately 1.5 miles to Halls Bayou, the flow is intercepted by the roadside ditch along Aldine-Westfield Road, which thus forms the de facto western boundary of the Watershed. Subsequent field visits and information requests have confirmed the lack of any operational drainage connection across Aldine-Westfield road. Therefore, the Watershed's western boundary is Aldine-Westfield Road, its northern boundary is Hopper Road, its eastern boundary is Shady Lane and the southern boundary is Trenton Road. It is on the west side of Shady lane that the drainage collects into the ditches that directly feed into Halls Bayou through four (4) outfalls. All streets have bar ditches rather than closed storm sewers. These ditches are routed to the four conduits that enter Halls Bayou directly east of Shady Lane. During dry weather, there is virtually no measurable flow into Halls Bayou. Two of the conduits are submerged and one is dry. Under moderate or high flow conditions, all drainage ditch conduits are submerged by bayou waters. As indicated in the Westfield Estates WPP– Phase I study, there are many cases of standing water in the ditches in dry weather, partly due to sediment deposition in the ditches and partly due to the many findings of OSSF failures (direct discharges or surfacing of home wastewater flows).

To approach the quantification effort, H-GAC, in conjunction with its consultant, PBS&J, has generated a representative outfall, or Community aggregate load discharge conduit, that would have sources from OSSFs, runoff flow, and bank flow. This approach is appropriate because:

- The overall area is small, about 0.35 square miles or 222 acres.
- There are 16 bar ditches for the 8 streets that are very similar as to length, dimensions, and slope.
- The ditches have a similar number of homes and documented conditions of malfunctioning OSSFs.
- The data available for each ditch is fairly limited, but if combined into a single representative ditch, is more robust.

The approach combines all the data for each ditch into a single outfall that would be represented with a simplified HSPF model, with average numbers of OSSFs and blockages. It would be calibrated to available observed data under dry and wet conditions. The model would be used to provide an estimate of approximate bacteria loads in all conditions and for a representative year.

The simplified HSPF modeling effort involved the following major steps:

Step 1. Delineation of Watershed:

Based on field visits conducted by H-GAC on December 16, 2008 and July 15, 2009 no cross culverts were found under the Aldine-Westfield Road from east to west at any streets in the Watershed. This finding has been confirmed with the County, who has indicated that the flow from the western portion of the Community does not flow east to Halls Bayou, being intercepted at Aldine-Westfield Road and conveyed elsewhere. As a result, Aldine-Westfield Road is the western boundary of the Watershed. Based on available aerial and GIS data, the study watershed shown in Figure C.1.1 was delineated and its size was determined to be 0.347 square mile or 222 acres. Assuming 45% impervious cover, which was estimated out of the aerial image of the area by comparing the roof, driveway, and street areas versus the total area the pervious and impervious areas for the HSPF model are 122 and 100 acres, respectively.

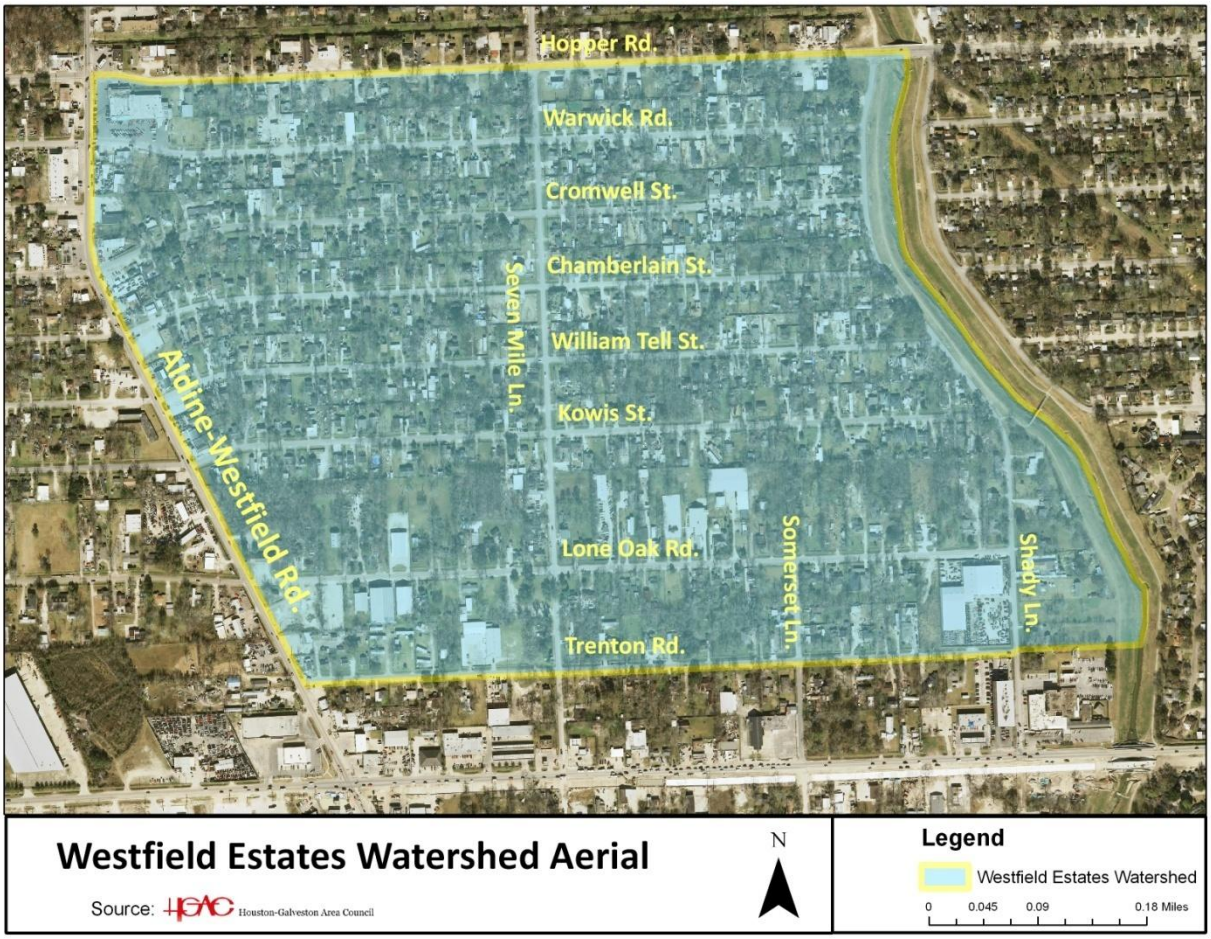

Figure C.1.1: Delineated Westfield Estates Watershed

Step 2. Development of Outfall FTABLE:

A field visit conducted by H-GAC on December 16, 2008 identified that four corrugated metal pipe (CMP) outfalls entered Halls Bayou from Westfield Estates. The CMPs are about 24 inches in diameter. These outfalls include a one-barrel CMP at Warwick, a one-barrel at Cromwell, a two-barrel at the north side of Kowis, and another two-barrel at the south side of Kowis. Assuming a total of six 24-inch CMP draining the entire Watershed, the relation of water depth, surface area, volume, and discharge rate for the hypothetical single outfall can be developed using the Manning's Formula. The developed relationship, as listed in Table C.1.1, was then entered in the HSPF model as the FTABLE of the discharge reach.

Table C.1.1: Developed FTABLE for Hypothetical Single Outfall

Flow (cfs)	Surface Area (ft2)	Volume (ft3)	Depth (ft)
0.00	0	0	0.0
2.61	24,430	3329	0.2
10.96	32,573	9106	0.4
24.505	37,317	16,137	0.6
42.16	39,893	23,890	0.8
62.55	40,716	31,978	1.0
84.05	40,716	40,067	1.2
104.75	40,716	47,819	1.4
122.29	40,716	54,851	1.6
133.34	40,716	60,628	1.8
125.11	40,716	63,957	2.0
1251.08	407,160	8,143,200	20.0

Step 3. Collection of Rainfall, Evaporation, and Evapotranpiration Data:

As shown in Figure C.1.2, Harris County Office of Emergency Management (HCOEM) operates and maintains two rain gages along Halls Bayou. Among them, Gage 1680 is closest to the study watershed so rain data associated with this gage were downloaded from the HCOEM web site and then processed into hourly data for use as input to the developed HSPF model.

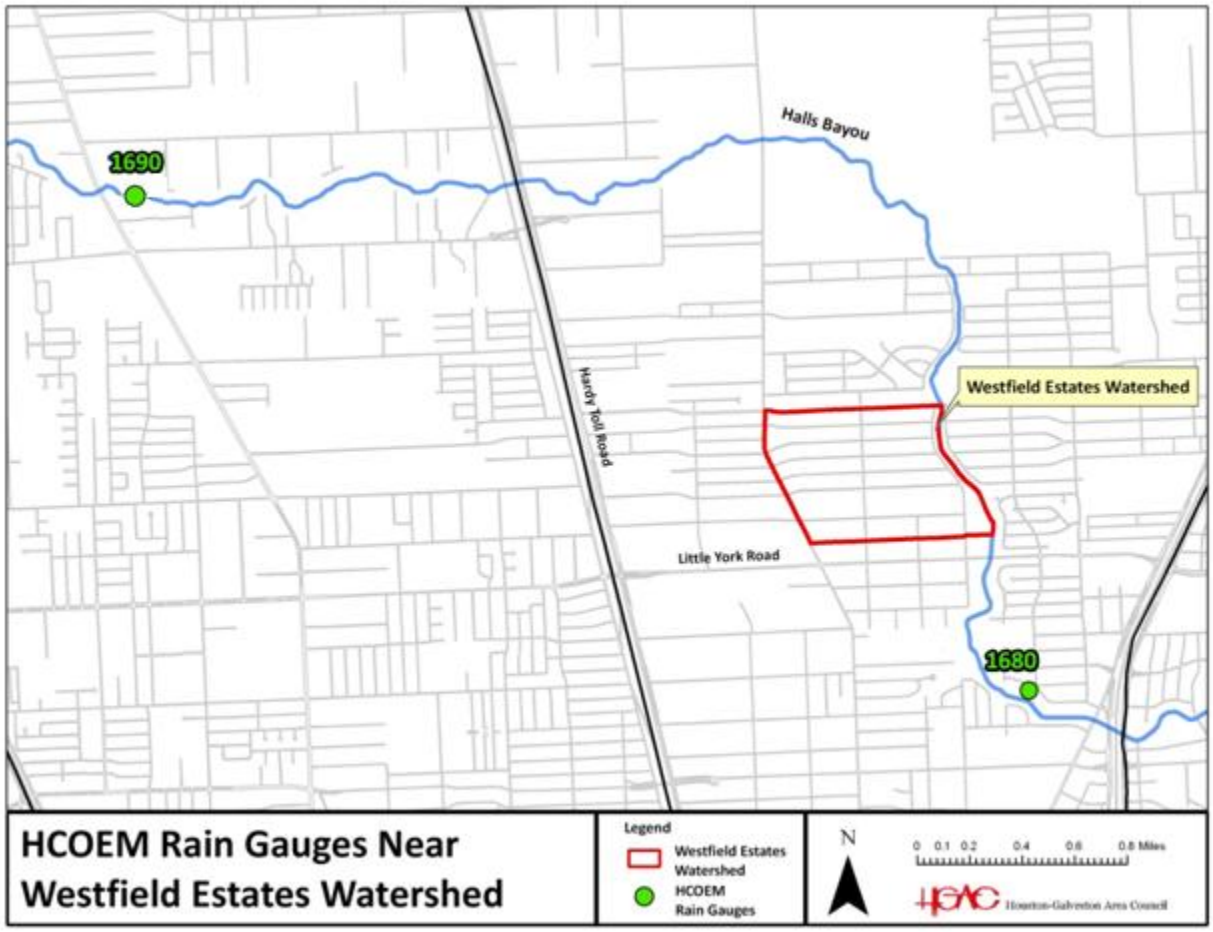

Figure C.1.2: HCOEM Rain Gages near Westfield Estates Watershed

The HSPF model also requires evaporation and evapotranspiration data. These data were retrieved from the Buffalo Bayou and Whiteoak Bayou Bacteria Total Maximum Daily Load Study (BB/WOB TMDL) where such data for the Houston area were collected and processed. While the BB/WO TMDL data stopped at 12/31/2003, it is assumed that the 2003 data can be adopted to represent the 2006 condition. The collection of actual data for 2006 would have required additional project resources. Figure C.1.3 shows the processed rainfall, evaporation, and evapotranspiration data for the Watershed HSPF modeling effort.

Step 4. Estimation of OSSF Flows[43]:

The Westfield Estates subdivision includes about 450-500 homes, based on aerial and field investigations conducted by H-GAC. Assuming 50% failure rate of the OSSFs about 250 systems are assumed to discharge untreated sewage under existing condition. Using a typical 90 gallons per day per person wastewater flow rate (Metcalf & Eddy, 1991, Page 27, Table 2-9) and an assumed three persons per household, a wastewater discharge rate of 270 gallons per day per OSSF was estimated. With the assumed 250 malfunctioning OSSFs, an existing-condition

[43] Metcalf & Eddy, Inc., 1991, Wastewater Engineering, 3rd Edition, McGraw-Hill, Inc., 1334 pp.

wastewater flow of 0.10444 cubic feet per second (cfs) or 0.008631 acre-feet per hour (ac-ft/hr) was entered into the developed HSPF model.

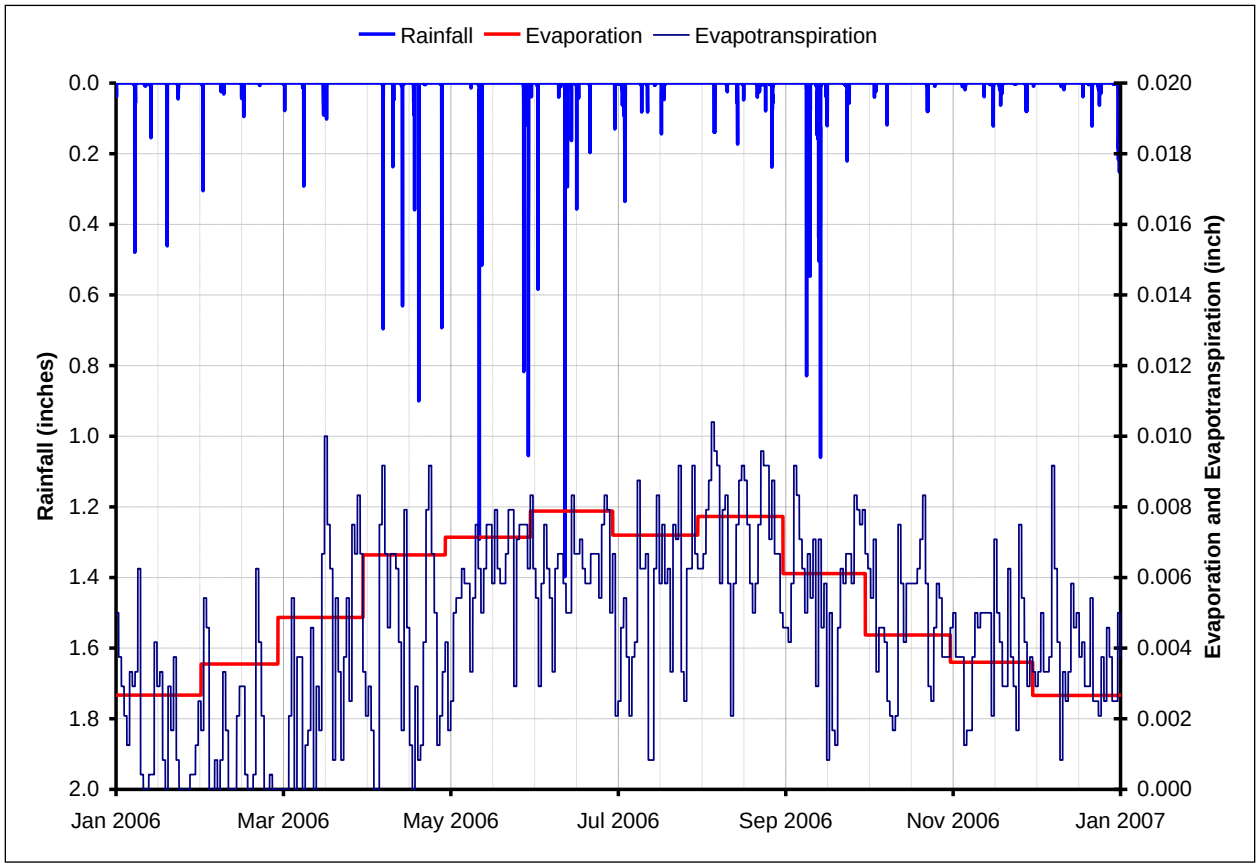

Figure C.1.3: Rainfall, Evaporation, and Evapotranspiration Data for HSPF Modeling

Step 5. Estimation of OSSF *E. coli* Loads:

Based on samples collected on 9/18/2006, 9/26/2006, and 11/28/2006 from the Westfield Estates ditches and outfalls, concentrations of *E. coli* were analyzed to allow the estimation of *E. coli* loads from the study watershed. Among the sample data, those from the ditches within the Westfield Estates, as listed in Table C.1.2, were considered representative of OSSF discharge and were used to estimate *E. coli* concentrations and loads from the malfunctioning OSSFs. Those sample data collected from or near the outfalls, as listed in Table C.1.3, were used as observed values to calibrate the HSPF model.

Among the three sampling events, 9/18/2006 and 9/26/2006 were labeled as dry-weather and 11/28/2006 as wet-weather. The collected *E. coli* data were further grouped based on these weather conditions and geometric means of the grouped data were determined, as listed in Tables C.1.2 and C.1.3.

Figure C.1.4 shows the ditch *E. coli* data in Table 18 together with the HCOEM rainfall data. The plot shows that September 18 and 26, 2006 were both dry days but with significant rainfalls preceding the sampling events. On the other hand, 11/28/2006 was a wet day with the daily total rainfall of 0.355 inches.

Table C.1.2: *E. coli* Data from within Westfield Estates

Location	Date	*E. coli* (MPN/dL)	H-GAC Wet/Dry	*E. coli* Geometric Mean (MPN/dL)
Cromwell	9/18/06	2,000	Dry	
Cromwell	9/18/06	> 2,400	Dry	
Cromwell	9/18/06	> 2,400	Dry	
Cromwell	9/18/06	> 2,400	Dry	
Cromwell	9/18/06	> 2,400	Dry	
Kowis	9/18/06	2,400	Dry	
Kowis	9/18/06	> 2,400	Dry	
Kowis	9/18/06	> 2,400	Dry	
Kowis	9/18/06	> 2,400	Dry	
Warwick	9/18/06	> 2,400	Dry	
Warwick	9/18/06	> 2,400	Dry	
Warwick	9/18/06	> 2,400	Dry	
Warwick	9/18/06	> 2,400	Dry	
William Tell	9/18/06	> 2,400	Dry	
William Tell	9/18/06	> 2,400	Dry	
William Tell	9/18/06	> 2,400	Dry	
William Tell	9/18/06	242,000	Dry	
William Tell	9/26/06	7,100	Dry	
Cromwell	9/26/06	1,400	Dry	
Cromwell	9/26/06	2,800	Dry	
Cromwell	9/26/06	800	Dry	
Cromwell	9/26/06	15,500	Dry	
Cromwell	9/26/06	13,300	Dry	
Kowis	9/26/06	242,000	Dry	
Kowis	9/26/06	16,100	Dry	
Kowis	9/26/06	> 242,000	Dry	
Kowis	9/26/06	120,300	Dry	
Trenton	9/26/06	700	Dry	
Warwick	9/26/06	19,900	Dry	
Warwick	9/26/06	6,600	Dry	
Warwick	9/26/06	> 242,000	Dry	
Warwick	9/26/06	1,500	Dry	
Warwick	9/26/06	12,000	Dry	
William Tell	9/26/06	> 242,000	Dry	
William Tell	9/26/06	45,700	Dry	
William Tell	9/26/06	21,400	Dry	7,301

Table C.1.2: *E. coli* Data from within Westfield Estates (Concluded)

Location	Date	*E. coli* (MPN/dL)	H-GAC Wet/Dry	*E. coli* Geometric Mean (MPN / dL)
William Tell	11/28/06	155,300	Wet	
Cromwell	11/28/06	68,700	Wet	
Cromwell	11/28/06	77,000	Wet	
Cromwell	11/28/06	29,900	Wet	
Cromwell	11/28/06	36,500	Wet	
Cromwell	11/28/06	36,500	Wet	
Cromwell	11/28/06	64,900	Wet	
Kowis	11/28/06	43,500	Wet	
Kowis	11/28/06	41,100	Wet	
Kowis	11/28/06	36,500	Wet	
Kowis	11/28/06	> 242,000	Wet	
Kowis	11/28/06	> 242,000	Wet	
Trenton	11/28/06	13,500	Wet	
Trenton	11/28/06	141,400	Wet	
Warwick	11/28/06	1,100	Wet	
Warwick	11/28/06	2,000	Wet	
Warwick	11/28/06	> 242,000	Wet	
Warwick	11/28/06	240,000	Wet	
Warwick	11/28/06	> 242,000	Wet	
Warwick	11/28/06	112,000	Wet	
Warwick	11/28/06	173,300	Wet	
William Tell	11/28/06	> 242,000	Wet	
William Tell	11/28/06	141,400	Wet	
William Tell	11/28/06	155,300	Wet	
William Tell	11/28/06	> 242,000	Wet	
William Tell	11/28/06	> 242,000	Wet	73,098

Table C.1.3: *E. coli* Data at Westfield Estates Outfalls

Location	Date	*E. coli* (MPN/dL)	H-GAC Wet/Dry	*E. coli* Geometric Mean (MPN/dL)
William Tell	11/28/06	> 2400	Dry	
Cromwell	11/28/06	1,000	Dry	
Cromwell	11/28/06	1,500	Dry	
Cromwell	11/28/06	1,000	Dry	1,377
Cromwell	11/28/06	13,800	Wet	
Cromwell	11/28/06	98,000	Wet	
Cromwell	11/28/06	13,800	Wet	
Kowis	11/28/06	141,400	Wet	40,305

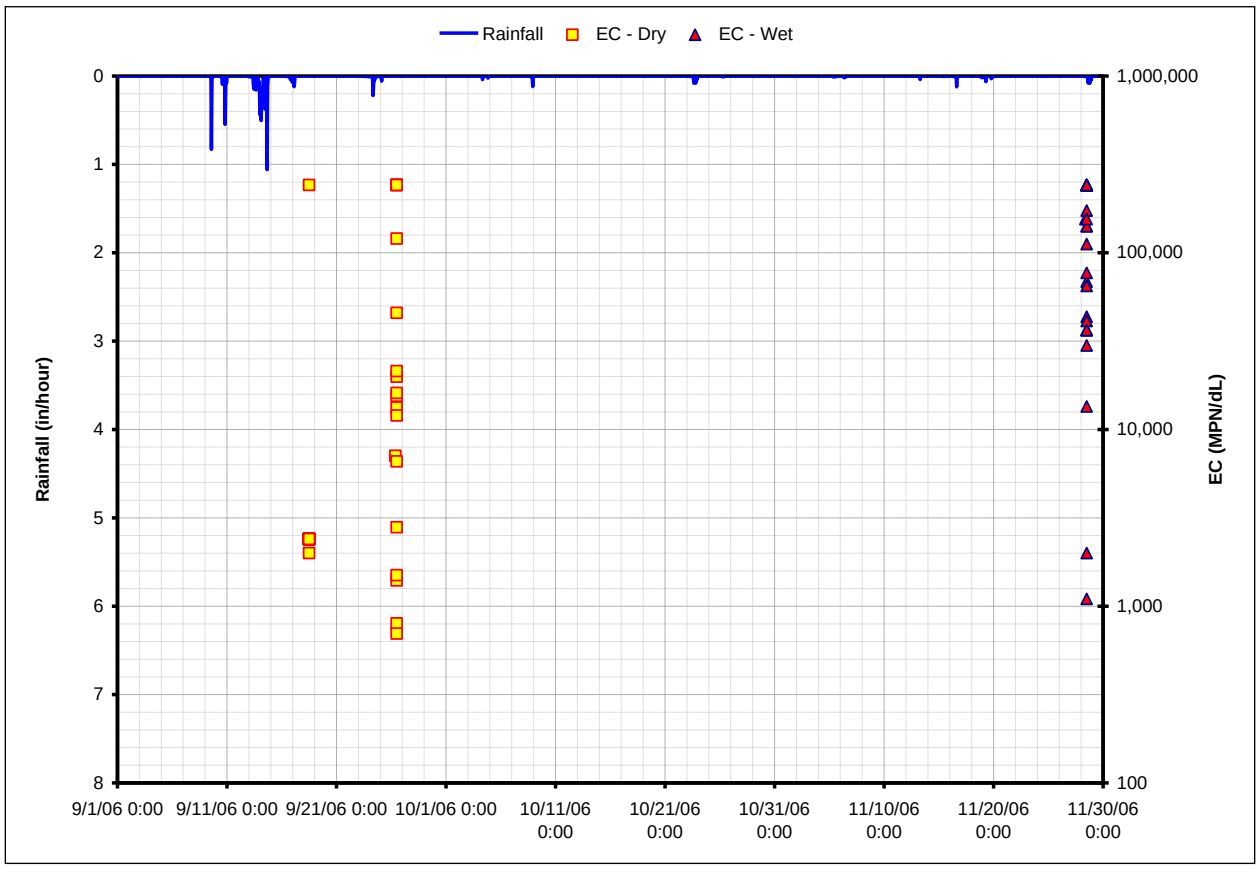

Figure C.1.4: Rainfall and Sampled *E. coli* Concentrations from Westfield Estates Ditches

The "dry-weather" geometric mean *E. coli* of 7,300 Most Probable Number per deciliter (MPN/dL) appeared to be very low comparing to typical *E. coli* levels in raw sewage. In addition, the rainfall events preceding the sampling dates as shown in Figure C.1.4 indicate that the samples might not qualify as "dry-weather" data. An examination of the data in Table C.1.2 indicated that many samples had *E. coli* greater than a detection limit of 242,000 MPN/dL. A decision was made to select a more representative *E. coli* level of 2,420,000 MPN/dL (one decade above the detection limit) as OSSF discharge concentration. Using this selected *E. coli* and the estimated 0.10444 cfs OSSF flow, an existing-condition OSSF *E. coli* loading rate of about 257.6 billion MPN per hour was calculated and entered into the developed HSPF model.

6. Calibration of HSPF Model:

Given limited project resources and field data, a thorough calibration and validation of the HSPF model was not feasible. Instead, most model parameters in the BB/WOB TMDL model were adopted assuming similar conditions in both studies. All project-related data in the TMDL model, including watershed areas, FTABLE, rainfall, OSSF flow and *E. coli* loads, etc., were

revised to match existing conditions for the Watershed. The model was then executed and the output *E. coli* levels were compared against the observed *E. coli* concentrations at the Westfield Estates outfall to Halls Bayou. Adjustments to HSPF model parameters were made to allow better match but no extensive model calibration was conducted.

Figure C.1.5 shows the HSPF output flow and *E. coli* levels at Westfield Estates Outfall together with observed *E. coli* concentrations. The figure indicates that the simulated *E. coli* levels were above the 11/28/2006 observed values but below the 9/18/2006 or 9/26/2006 data. Attempts were made to improve the matching between the observed and simulated values, but unsuccessful due to the lack of available flow data at the outfall to verify the modeled outflow values during the sampling events. A closer examination of the mismatch revealed the following potential causes of the mismatch:

- The HCOEM rain gage is outside of the study watershed and the actual rainfall within the Watershed might be quite different from the gage data.
- Based on the rainfall data, the sampling events appeared to occur after and in between significant rainfall events and the ditches were still filled with stormwater runoff that affected the *E. coli* levels.
- There could be high noise or variability associated with observed *E. coli* data. While the developed HSPF model could be further improved through a thorough additional data collection and calibration efforts, it is considered sufficient to support an *E. coli* load reduction simulation exercise.

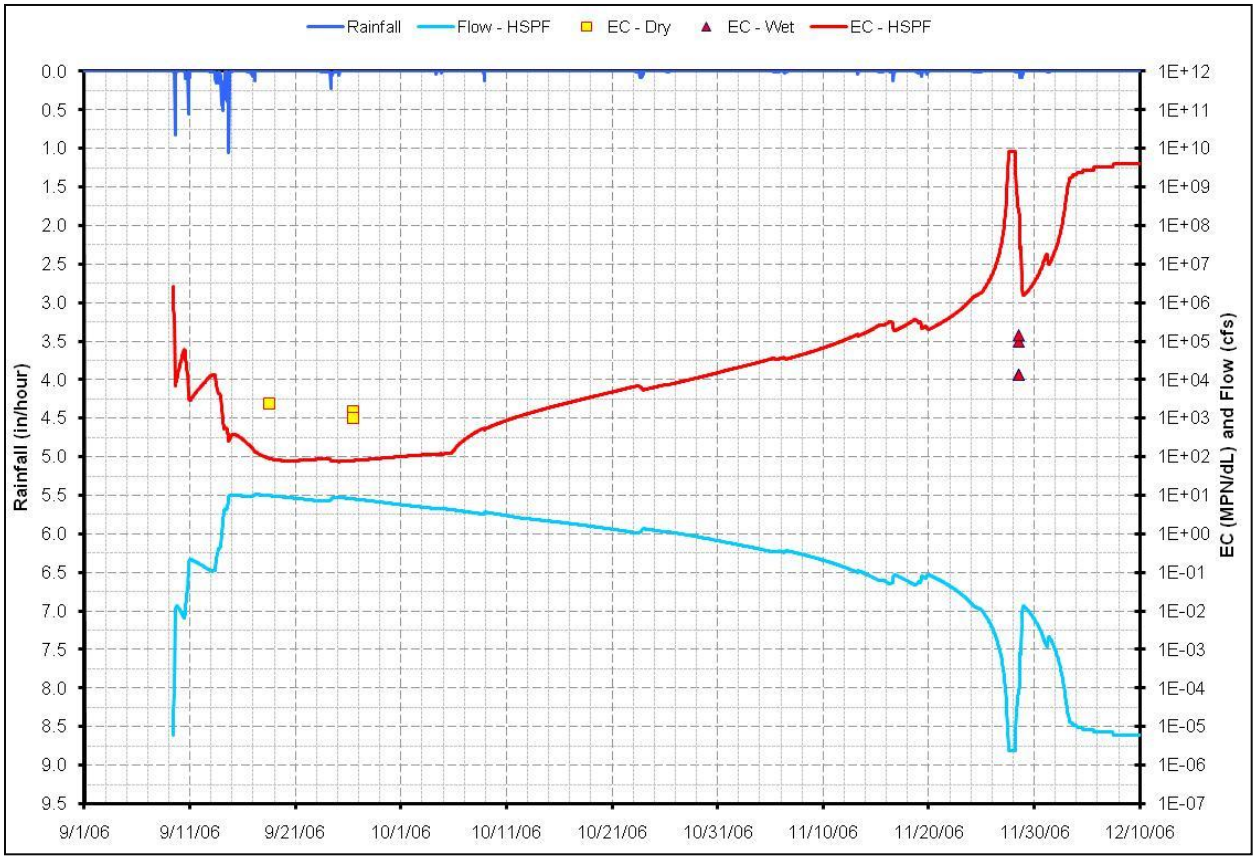

Figure C.1.5: Modeled and Observed *E. coli* Levels at Westfield Estates Outfall to Halls Bayou

7. Simulation of Potential *E. coli* Load Reduction:

Using the same wastewater discharge rate of 270 gallons per day per OSSF, but assuming that 70% of the 250 malfunctioning OSSFs (175 OSSFs) would be fixed, a proposed-condition wastewater flow of 0.03133 cfs or 0.00259 ac-ft/hr was entered into the calibrated HSPF model.

Using the selected dry-weather geometric mean *E. coli* of 2,420,000 MPN/dL and the estimated 0.03133 cfs OSSF flow, a proposed-condition OSSF *E. coli* loading rate of about 77.3 billion MPN per hour was calculated and entered into the developed HSPF model. The proposed-condition HSPF model was then executed and the output of both existing and proposed flow and *E. coli* levels are shown in Figure C.1.6. The figure shows a reduction in the overall *E. coli* levels although there are periods when the flows dry up and the proposed-condition *E. coli* levels go above the existing levels. However, the repair of 175 OSSFs is expected to reduce the total annual *E. coli* load by 9.60×10^{14} MPN or about 56.8%. This conclusion is based on the assumption that the *E. coli* buildup and stormwater wash-off loads in the Watershed stay unchanged. However, it is reasonable to expect that a reduction in the surface discharge of OSSF effluent will reduce the rainfall runoff loads. Further studies would be needed to better quantify the effects of reducing the number of malfunctioning OSSFs on *E. coli* buildup and wash-off in the Watershed.

The 77.3 billion MPN/hr translates to 6.77×10^{14} MPN per year. This is the *E. coli* load/input to the system/model from OSSFs after 175 malfunctioning OSSFs have been fixed. The 9.6×10^{14} MPN per year *E. coli* reduction is the difference between the total *E. coli* from the system before and after the fixing of the 175 OSSFs. Thus, the OSSF load is an input to the HSPF model while the load reduction is calculated using the output of the model.

Note that the total *E. coli* from the system (model output) includes the OSSF input, the sediment *E. coli* source, the rainfall-runoff *E. coli* wash off, the *E. coli* decay, the *E. coli* settling, etc (all those facets simulated by the HSPF model). The model used calibrated Buffalo Bayou and Whiteoak Bayou HSPF model parameters, so all bacteria dynamic parameters are kept the same as similar area studies, but the OSSF flow volume and *E. coli* load incorporated Westfield specific numbers.

Thus, below is an *E. coli* mass balance:

- Existing condition (250 malfunction OSSFs):
  - OSSF *E. coli* load: 0.00258×10^{14} MPN per hour or 22.6×10^{14} MPN per year.
  - Total *E. coli* from the Watershed: 16.9×10^{14} MPN per year (indicating the effects of *E. coli* decay and storage in the system).
- Proposed condition (75 malfunction OSSFs or with 175 fixed):
  - OSSF *E. coli* load: 0.000773×10^{14} MPN per hour or 6.77×10^{14} MPN per year.
  - Total *E. coli* from the Watershed: 7.30×10^{14} MPN per year (indicating the effects of additional *E. coli* sources from runoff and sediment).
- Reduction in *E. coli* load = $16.9 \times 10^{14} - 7.30 \times 10^{14} = 9.6 \times 10^{14}$.
- Percent reduction = $9.6 \times 10^{14} / 16.9 \times 10^{14} = 56.8\%$.

Comparing to the *E. coli* load from the 250 malfunctioning OSSFs (22.6 x 10^{14} MPN per year), the reduction of 9.6 X 10^{14} MPN per year is not greater. However, the reduction is greater than the total *E. coli* load from the remaining 75 malfunctioning OSSFs (6.77 x 10^{14} MPN per year).

It is not assumed that the total *E. coli* load from the Watershed is coming from the OSSFs. However, it is assumed that effluents from the OSSFs contain 2,420,000 MPN/dL *E. coli*. That is, this *E. coli* concentration in dry weather sampling events is based on OSSF contribution, in that the pools of standing water in the ditches are attributable to malfunctioning OSSFs.

Thus, the 2,420,000 MPN/dL *E. coli* concentrations are used to calculate *E. coli* loads from the OSSFs into the Watershed. The HSPF model takes this load as one *E. coli* input and simulates other *E. coli* processes including wash off from the Watershed by rainfall-runoff, re-suspension and settling of *E. coli* in sediment, etc., and the final outcome is the total *E. coli* load from the Watershed. It is expected that, due to decrease in nutrient loading from the OSSFs, that some degree of nonhuman bacterial re-growth will be inhibited, representing a minor reduction.

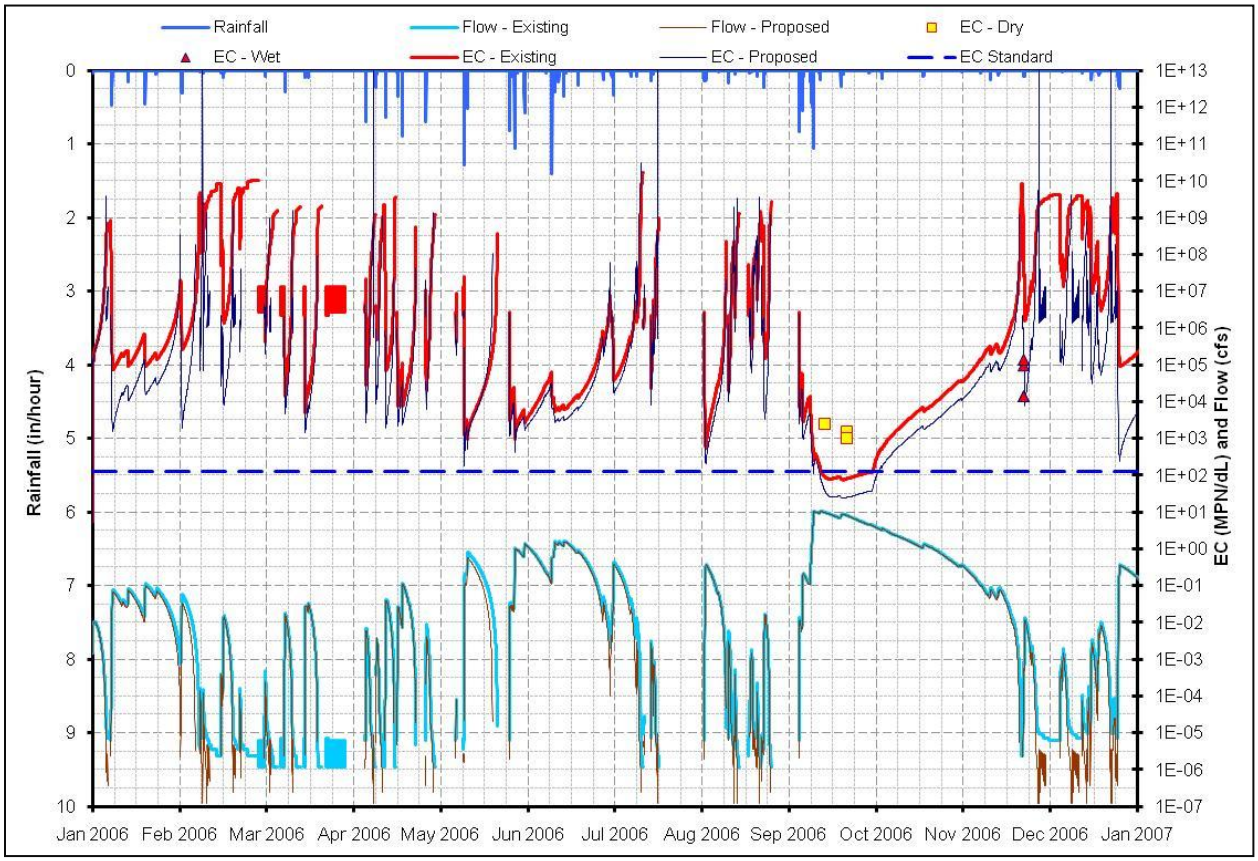

Figure C.1.6: Existing and Proposed Flow and *E. coli* Levels at Westfield Estates Outfall

C.2 Halls Bayou Existing Conditions and Pollutant Load Estimates

Load Duration Curve for Halls Bayou

The analysis uses three monitoring stations, 11126, 11127, and 17490. (Figure C.2.1) Station 11126 is at the same location as USGS gage 08076500, Halls Bayou is at Jensen Drive, approximately 1 mile downstream of Westfield Estates. Station 17490 is at Halls Bayou at Airline Drive, approximately 1 mile upstream of the Community, and Station 11127 is two miles upstream at Halls Bayou and Tidwell. The procedure was as follows:

- Review flow and bacteria data, identify data gaps and clean up data.
- Generate flow data at Station 17490 and 11127. Currently there is no flow gage at either station. We understand that some flow observations have been made at the monitoring stations. These will be compared with the USGS gage flows. The USGS gage flows at Jensen Drive, station 11126, will be applied at Stations 17490, and 11127. This is reasonable considering the low conveyance and H-GAC's studies that show low flow rates at all three station locations are nearly identical. Wastewater dischargers between the three monitoring stations will be examined. It is assumed that the loads developed will be representative.
- Develop flow duration curves at the three monitoring stations based on daily flow data.
- Develop load duration curves at the two monitoring stations from the flow duration curves and the water quality criterion for *E. coli* bacteria.
- Compute daily loads from the bacteria data by multiplying the bacteria concentration by the average daily flow on the day the sample was collected.
- Compute percentage criteria exceedence percentages and their distribution by comparing daily loads from bacteria data and the load duration curves.
- Document analysis and results in a report.

Daily flow data were obtained from the USGS website for gage 08076500. The daily discharge data are available from 10/01/1952 to 8/20/2008. There is a gap between 10/1/1993 and 9/30/2000. The daily flow data from 10/1/1980 to 9/30/2007 (20 years of data excluding the data gap) were used for the analysis. This period was selected after reviewing the low flow portion of the USGS gage data. As shown in Figure C.2.1, the low flow trended upward from the 60s up to mid to late 70s and then more or less stabilized. Since the low flow reflects wastewater treatment plant (WWTP) effluent related to development in the Watershed, 1980 seems to be a reasonable cut-off point of the flow period to be used. Since there is no flow record at Stations 17490 and 11127, the flows at these locations need to be estimated. However, resent H-GAC flow monitoring show that low flow rates at all three stations are very similar, which should make estimations relatively close to the actual flow values.

The USGS flows at Gage 08076500 were separated into two components – a low flow estimated to be about 8 cfs from WWTP discharges and the rest being rainfall runoff. The runoff at the other two stations was estimated based on drainage area ratios. The low flows were estimated based on wastewater discharges.

It is noted that Station 11127 is listed as a tidal stream station in the TCEQ database. This is a database error, which has been reported to TCEQ by H-GAC. Halls Bayou is a tributary of Greens Bayou, which flows into the Houston Ship Channel.

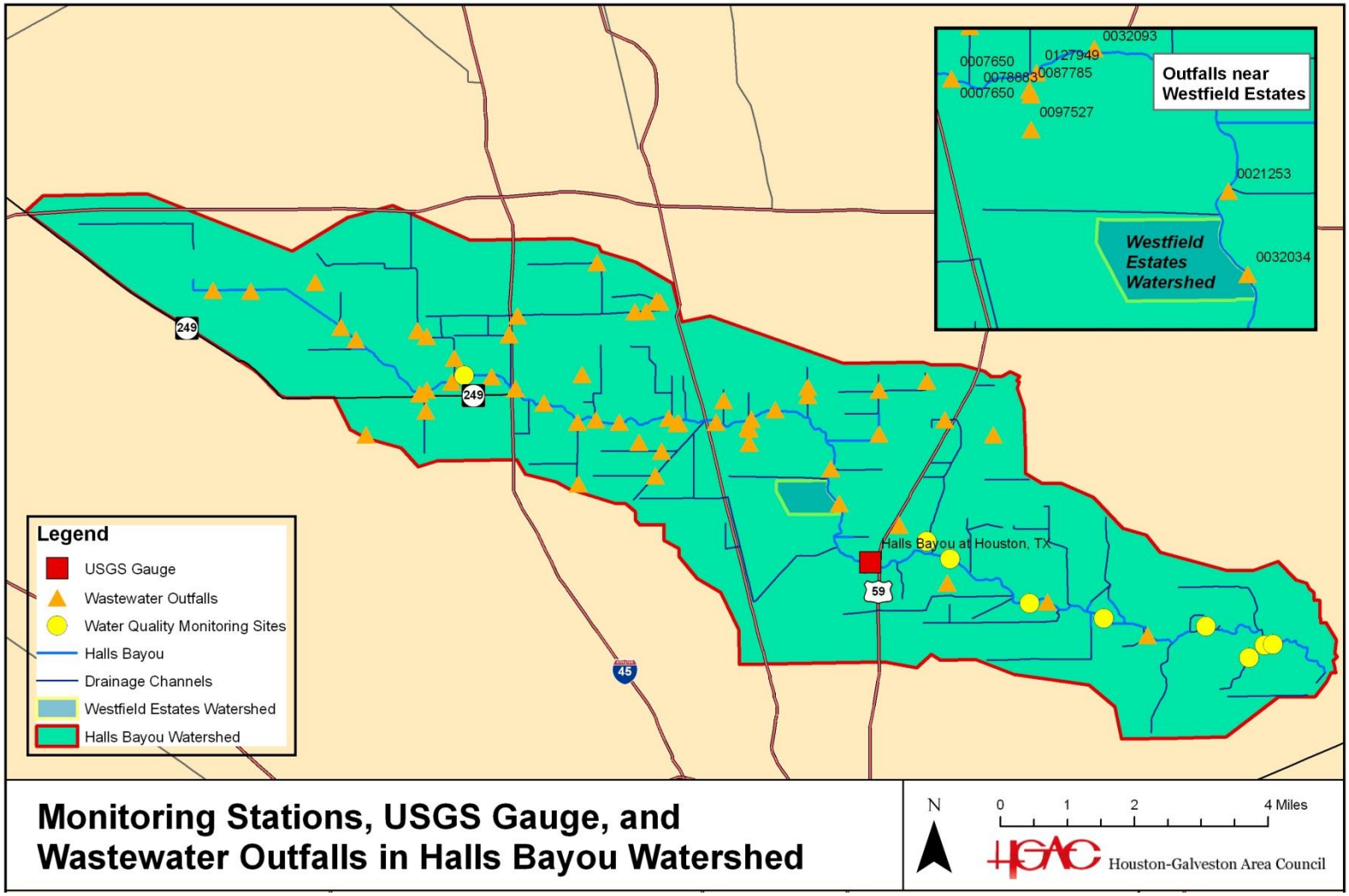

Figure C.2.1: Locations of Monitoring Stations, USGS Gage, and Wastewater Outfalls in Halls Bayou Watershed

The station location is far upstream from the Houston Ship Channel. Moreover, this location is within the stream modeled in the TCEQ's Halls Bayou QUAL-TX model for wasteload evaluation. Apparently there is no tidal effect at this location and the following analysis was performed without considering tidal effect.

Information of wastewater dischargers was obtained from H-GAC and the EPA's Permit Compliance System (PCS) database (http://www.epa.gov/enviro/html/pcs/pcs_query_java.html). The locations of the WWTP outfalls are shown in Figure C.2.1.

One of the major dischargers is the City of Houston plant with permit number 10495-016 and permitted flow of 7 MGD. This plant is more than 2 miles upstream of Westfield Estates. The others are all small plants with permitted flow less than 0.1 MGD. After reviewing monthly self-reported flow data of the Houston plant from 2001 to 2007, 3 MGD (4.64 cfs) appears to be a reasonable estimate of the low flow component between the USGS gage and Station 11127.

There are 19 WW outfalls upstream of Station 17490. Six of them with a total permitted flow of about 4 MGD existed before 1980. The other plants added a total of about 1.8 MGD permitted flow but came online at various times after 1980. The level of details of this analysis does not warrant a detailed accounting of the WW flows contributed by these dischargers. As the low flow is typically about half of the permitted flow, 3 MGD (4.64 cfs) was used as the low flow component upstream of Station 17490.

The following procedure was used to estimate the flow at Station 11127. First, 8 cfs was subtracted from the flow at USGS gage 08076500 (negative values were replaced with zeros). The resulting value was multiplied by the ratio of the drainage area at Station 11127 (39.11 square miles) to the drainage area at the gage (28.72 square miles) to obtain the estimate of runoff at Station 11127. Then the low flow, which consists of 8 cfs from upstream of the USGS gage and 4.64 cfs between the gage and Station 11127, was added to the runoff estimate to obtain the flow estimate at Station 11127.

The procedure to estimate the flow at Station 17490 was similar. First, 8 cfs was subtracted from the flow at USGS gage 08076500 (negative values were replaced with zeros). The resulting value was multiplied by the ratio of the drainage area at Station 17490 (13.6 square miles) to the drainage area at the gage (28.72 square miles) to obtain the estimate of runoff at Station 17490. Then the low flow from area upstream of Station 17490 (4.64 cfs) was added to the runoff estimate to obtain the flow estimate at Station 17490.

The flow duration curve at each station was then calculated. A flow duration curve relates flow values to the percent of time those values have been met or exceeded. The full range of stream flows is considered. Low flows are exceeded a majority of the time, while floods are exceeded infrequently. Figure 3 shows the flow duration curves at the three stations. For Stations 11127 and 17490, near the low flow end the curve appears flat. This is an artifact of the estimation procedure. Subtracting 8 cfs from the USGS flows resulted in negative values on some days and were replaced with zeros. After adding the low flow, the flows on these days became all at the value of estimated low flow.

The load duration curve is the flow duration curve multiplied by the *E. coli* criterion. Typically the single sample criterion (394 MPN/dL) was used. We also included the load duration curve calculated from the geometric mean criterion (126 MPN/dL). Figures C.2.2, C.2.3, C.2.4 show the load duration curves for Stations 17490, 11126 and 11127 respectively.

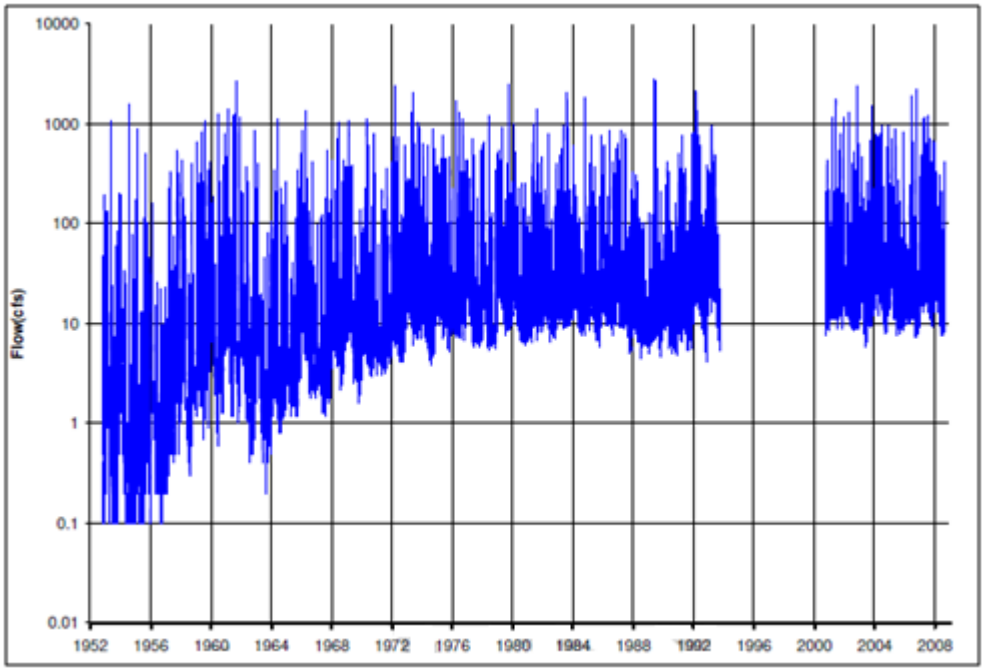

Figure C.2.2: USGS Daily Flow at Gauge 08076500

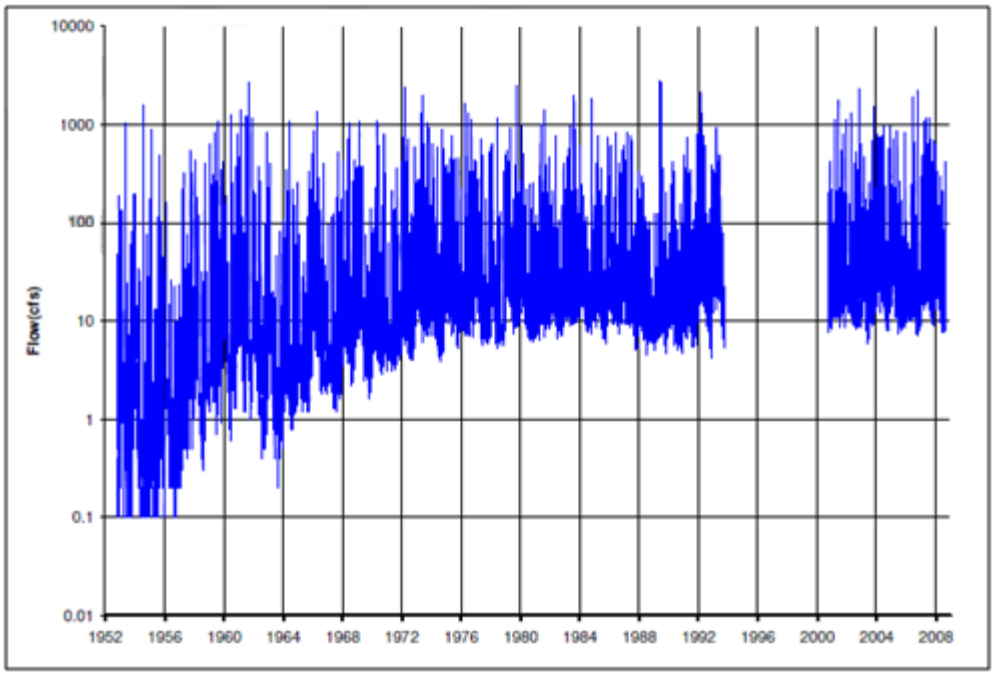

Figure C.2.3: Flow Duration Curves for Stations 17490, 11126 and 11127

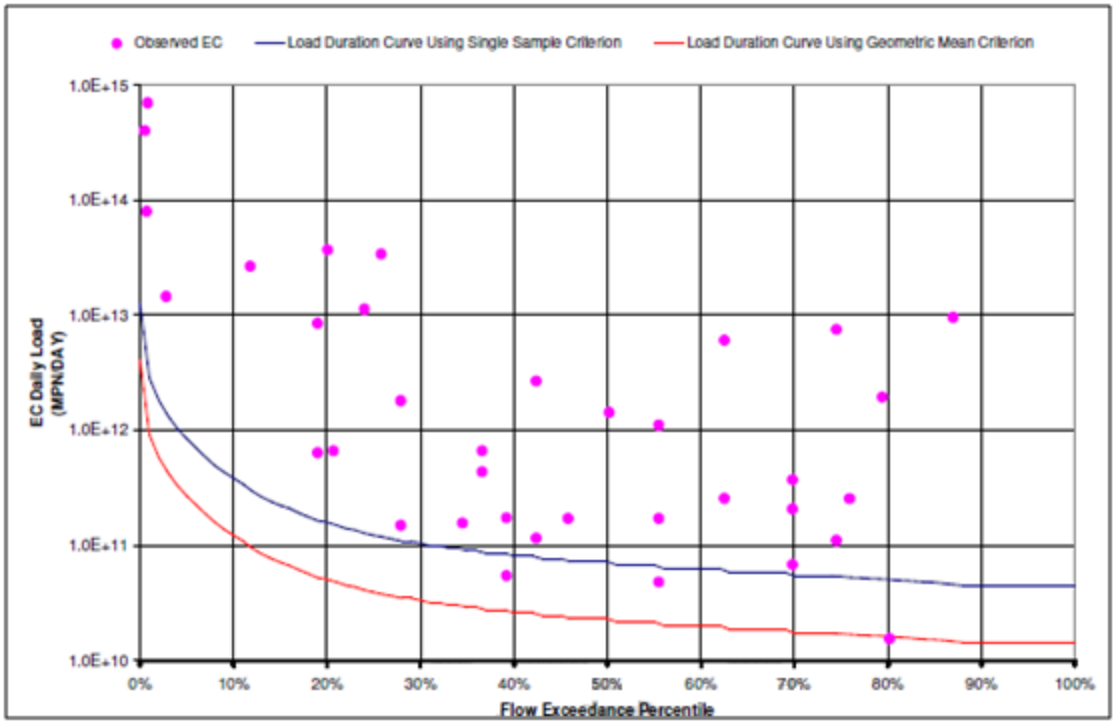

Figure C.2.4: Load Duration Curve for Station 17490

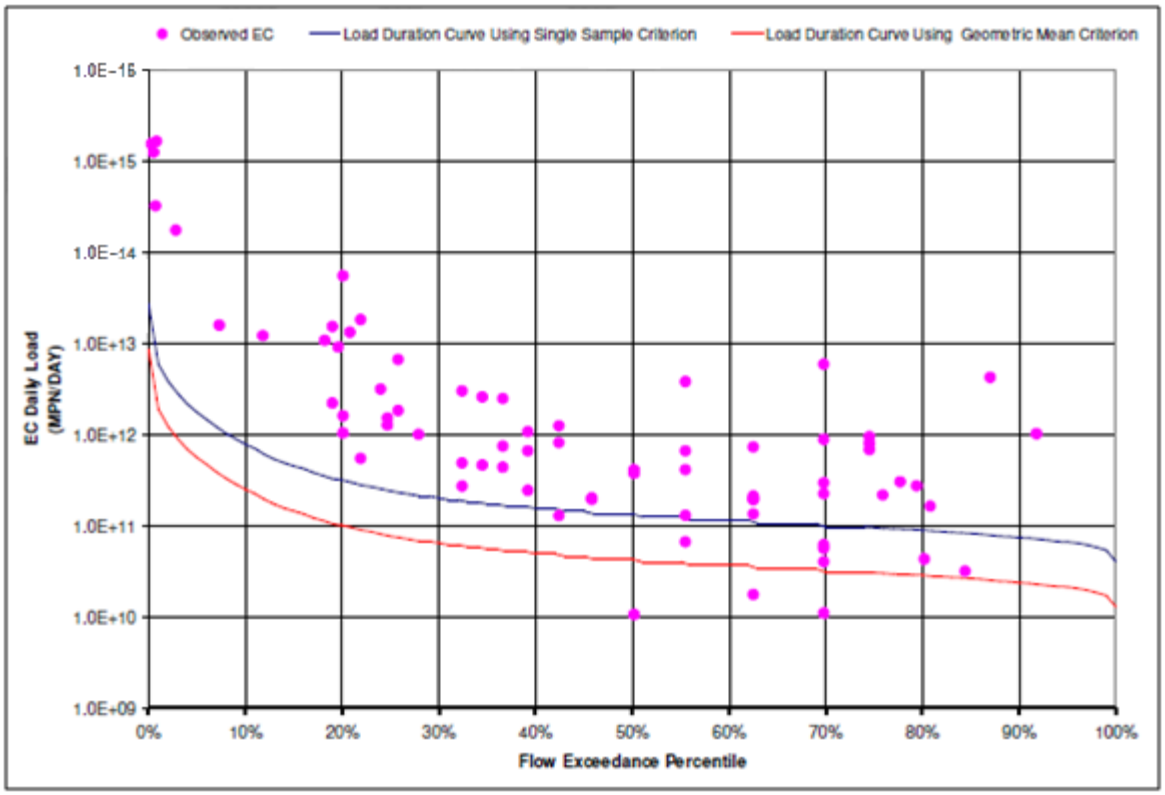

Figure C.2.5: Load Duration Curve for Station 11126

Observed *E. coli* data for the three monitoring stations were collected between 2001 and 2008. The daily bacteria load was calculated as the product of the daily flow rate and the observed concentration. The calculated loads were also shown in Figures C.2.1 to C.2.6. At all three stations, when the flow is above the approximate median flow, all the *E. coli* data exceed the criteria. This is indicative of contributions of nonpoint sources. At lower flows, most data exceed the criteria but there are some that are below the criteria, which is indicative of a primarily point source, but also nonpoint source pollution.

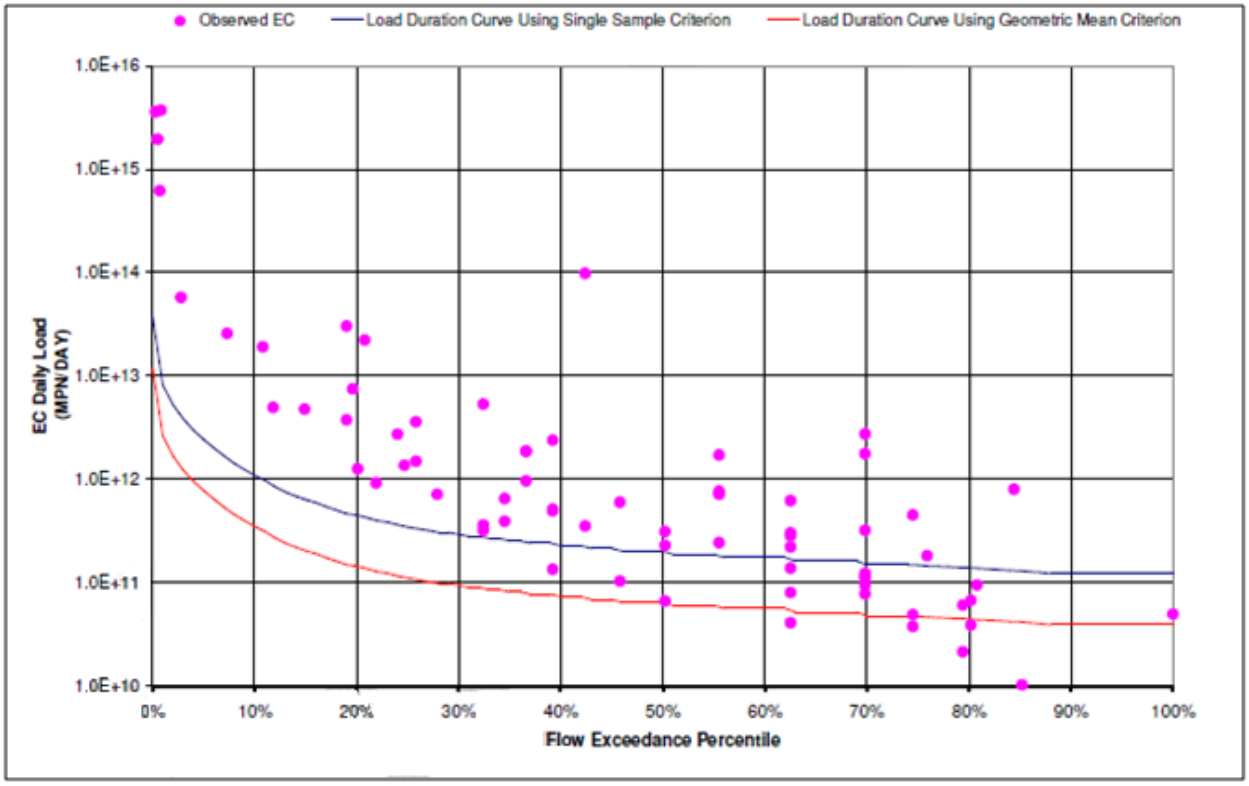

Figure C.2.6: Load Duration Curve for Station 11127

The Westfield Estates subdivision has the highest concentration of malfunctioning OSSFs in the H-GAC region. Other areas of Halls Bayou also have malfunctioning OSSFs but not to the same degree. By conducting repair and replacement of malfunctioning OSSFs in this area and working to educate the residents about proper OSSF care and maintenance, this project will serve as a pilot to determine if other areas facing the same challenges should also undergo this type of corrective action.

Appendix D - Implementation

D.1 Scope of Work

Westfield Estates Watershed Protection Plan Implementation-
Houston Galveston Area Council

Scope of Work

Problem / Need Statement
The Westfield Estates Watershed is located in northeast Harris County, Texas adjacent to Halls Bayou. It is entirely within the EAMD. The Community of Westfield Estates, which covers 65% of the watershed, has the highest need for public sewer services in Harris County (Harris County Precinct 2 Study, 2007). The community of approximately 700 homes is served entirely by private OSSFs. Westfield Estates has a disproportionate number of minorities, disabled, under-educated, foreign-born, non-English-speaking, lower income and higher average family size than Houston as a whole, Texas, or the United States.

High numbers of county OSSF violations occur in the watershed. Stagnant black-colored water is found in ditches during dry weather from which a strong "sewer" odor emanates. Elevated levels of bacteria (>100,000 MPN/100 ml) were found at most of the 20 sites examined in Westfield Estates in the first phase of this work, Failing Septic System Initiative Phase I, concluded in 2007; (Phase I). Bacteria in ditch water flows through street ditches in the watershed, especially during rain events (11,800 to 141,000 MPN/100 ml). Presumably, the majority of the contamination comes from malfunctioning OSSFs. However, FSSI-I also indicates that a significant amount of bacterial water quality issues comes from nonhuman sources (65-70%), primarily chickens and dogs, with a component(s) still unknown. Bacteria levels 6 to 600 times the Water Quality Standards both in the Westfield Estates Watershed may pose a potential for human illness. These levels also exceed State Criteria for contact recreation.

A permanent solution to the human bacterial source problem (municipal sewer service) is unlikely to occur in the foreseeable future because of logistics, resident income, and funding requirements ($16 million). Interim solutions, which include remediation or replacement of existing OSSFs plus maintenance agreements, and BMPs for decreasing bacterial contamination from both human and nonhuman sources, coupled with a WPP pose a viable option to reducing the bacteria load in the watershed.

The Westfield Estates Watershed Protection Plan (Westfield Estates WPP) proposes bacterial water quality issues management using structural OSSF construction or modification and behavioral BMP components.

Education and public outreach are critical to the success of this project. In a historically underserved community where services were promised before but not delivered, credibility must be established and maintained. Resident's participation in the Phase I Town Meeting was excellent and interest was high. A stakeholder's group, which includes elected officials with jurisdiction over the Community has been established and is involved in a watershed protection plan for the area. After funding is confirmed, residents will be actively engaged in project process/progress, and in the development of updates to the watershed protection plan.

General Project Description
The Westfield Estates WPP proposes to reduce bacterial water quality issues in the Westfield Estates Watershed or alternately the bacteria load in another EAMD community via:

- Maintenance, repair, and/or replacement of malfunctioning OSSFs or installation of OSSFs;
- Development and implementation of BMPs to reduce water quality issues (bacteria) from human and nonhuman sources;
- Updating the Watershed Protection Plan to includes specifics needed to address bacteria water quality issues;
- Broadening the base of stakeholders group for the watershed protection plan; and
- Transferring "ownership" of watershed protection plan to the stakeholders group. H-GAC will chair the group, provided funding is provided by TCEQ after the implementation project is completed.

In the Westfield Estates WPP, the primary benefit from inspection, repair, remediation, installation, and/or replacement of malfunctioning systems is a direct reduction of human source bacteria in the watershed. To monitor progress, bacteria levels will be determined pre- and post construction and at locations on Halls Bayou above and below the watershed outfall(s) throughout the study. H-GAC will repeat watershed and water body monitoring for bacteria at previously examined sites (FSSI- Phase I) to quantify the amount and source of bacteria reduction leading to quantifiable load reduction following implementation. Additional success will be measured by a decrease in OSSF violations. The absence or reduction of standing water in ditches may also be a measure. Residents whose OSSFs are replaced or repaired will be required to sign a maintenance agreement managed by the Freshwater supply District providing the area with water service.

BMPs to reduce the nonhuman water quality issues (bacteria) will be developed and implemented. Additional monitoring will identify remaining nonhuman sources from FSSI-I and quantify the reduction. Public outreach will educate residents on the proper maintenance of OSSFs, and involve them in the development and implementation of BMPs for nonhuman bacteria sources.

<u>Project outcomes:</u>

- Repair, install, replace, or provide maintenance to residential OSSFs depending on available funds and site suitability.
- Develop and implement BMPs for nonhuman bacterial sources (e.g. dogs and chickens).
- Hold town meetings two times per year to share progress with watershed residents.
- Convene final town meeting "Wrap-Up" and transfer of the Watershed Protection Plan to the PSG. H-GAC will facilitate the PSG, provided funding is provided by TCEQ after the implementation project is completed.

- Provide education on BMPs on behavioral modification and care of OSSFs, including maintenance agreements with responsible entity, (e.g. FWSD).

Secondary benefits from the project:

- Maintain drainage ditch in flood prone area previously hindered by presence of bacteria.
- Estimate human health issues associated with malfunctioning OSSFs before/after project.
- Possible reduction of human illness associated with bacterial contamination, estimated by EPA at 5% of the population in the Community (est. 150 persons).
- Develop Water Quality Issue (Bacteria) Reduction Plan useful for TMDL.
- Establish broad-based acceptance of a Watershed Protection Plan.

TASK 1: PROJECT ADMINISTRATION and MANAGEMENT

Goal: *To effectively coordinate and monitor all technical and financial activities performed under this contract, prepare regular progress reports, and manage project files and data.*

Task 1.1 **Project Oversight –** The GRANTEE's Project Manager will provide technical and fiscal oversight of the GRANTEE project staff and/or sub grantee(s)/subcontractor(s) to ensure Tasks and Deliverables are acceptable and completed as scheduled and within budget. With the TCEQ Project Manager's authorization, the GRANTEE may secure the services of sub grantee(s)/subcontractor(s) as necessary for technical support, repairs and training. Project oversight status will be provided to the TCEQ with the Quarterly Progress Reports.

Task 1.2 **Quarterly Progress Reports –** To be submitted to TCEQ by the 20th of the month each state fiscal quarter for incorporation into the Grant Reporting and Tracking System (GRTS). Progress reports will contain a level of detail sufficient to document the activities that occurred under each task during the quarter, and contain a detailed tracking of deliverable status under each task.

Task 1.3 **Reimbursement Forms-** Reimbursement forms will be submitted to the TCEQ by the last day of the month following each state fiscal quarter.

Task 1.4 **Communication Plan -** The GRANTEE Project Manager will maintain regular telephone and/or email communication with the TCEQ Project Manager regarding the status and progress of the project in regard to any matters that require attention between Quarterly Progress Reports. This will include a call or meeting each January, April, July, and October. Minutes recording the important items discussed and decisions made in each call will be attached to each Quarterly Progress Report. Matters that must be communicated to the TCEQ Project Manager in the interim between QPRs include:

- Requests for approval of activities or expenditures those are not specifically included in the scope of work
- Notification in advance when GRANTEE has scheduled public meetings or events, initiation of construction, or other major task activities under this contract
- Events or circumstances that may require changes to the budget, scope of work, or schedule of deliverables (Such information must be reported within 72 hours of discovering these events or circumstances)

Task 1.5 **Contractor Evaluation -** GRANTEE will participate in an annual Contractor Evaluation.

Task 1.6 **Project Fact Sheet –** The Project Manager will develop a one page fact sheet of the project using the TCEQ NPS Projects Template. The fact sheet will briefly describe what the project is going to accomplish, gives background information on why the project is being conducted, the current status of the project and lists who is involved in the project. The project fact sheet will be submitted to the TCEQ within 60 days after receipt of fact sheet template from TCEQ. The fact sheet will be updated annually and submitted with the fourth quarter progress report. The fact sheet may be updated more often, as the project status changes. The fact sheet will be published on the GRANTEE's website after approval from the TCEQ Project Manager, which will be within 30 days of submission by the Grantee.

Measures of Success: Adherence to the TCEQ administrative requirements; timely completion and submittal of progress reports and deliverables.

Deliverables:

- **Quarterly Progress Reports - 6/15/2009; 9/15/2009; 12/15/2009 3/15/2010; 6/15/2010; 9/15/2010; 12/15/2010 3/15/2011; 6/15/2011; 8/31/2011**
- **Reimbursement Forms- 6/30/2009; 9/30/2009; 12/31/2009 3/31/2010; 6/30/2010; 9/30; 2010; 12/21/2010 3/31/2011; 6/30/2011; 9/30/2011**
- **Communication Plan- 6/15/2009; 9/15/2009 12/15/2009 3/15/2010; 6/15/2010; 9/15/2010; 12/15/2009 3/15/2011; 6/15/2011; 9/15/2011;**
- **Contractor Evaluation- 8/31/2009; 8/31/2010; 8/31/2011**

- **Project Fact Sheet-** **60 days from receipt of template after contract execution (6/15/2010; 6/15/2011)**

TASK 2: STAKEHOLDER ADVISORY GROUPS

Goal: *To lead the watershed-based component of the Watershed Protection Plan and Project by continued broadening and completing development of a balanced and diversified Stakeholder Advisory Group.*

Task 2.1 **Stakeholder Advisory Group (SAG) Interface –** Utilizing the existing partner network, which includes local officials, county government, state and federal government, special interest groups, environmental groups, developers, and citizens, SAG will provide advice on plan updates, QAPP amendments, scope of work, implementation phase, and community education. The group will determine guidelines for future SAG role, involvement, and responsibility for the Plan after completion of implementation phase. This group will work toward Community acceptance of project, promoting continuing education, support maintenance programs, BMPs, and development and of long term sustainability of watershed protection plan. Meetings will be held on a regular basis. This group will transition to assuming the leadership role in managing the watershed protection plan at the end of the project. Additional stakeholders may be added to the group as the need and opportunity arises.

Task 2.2 **Stakeholder Advisory Group Meetings -** Hold meetings with the Stakeholder Advisory Group to establish priorities and focus work effort. Meetings will be held on a regular basis to provide status of work progress to the group and obtain input on next steps. Stakeholders will review and approve the plan prior to finalization.

Task 2.3 **Dissemination of Information on Status of Project –** Use Stakeholder Advisory Group meetings to disseminate project information held on a quarterly basis the first year and thereafter as warranted by developments in the project (at least twice a year), and at project conclusion. Town Meetings in English and Spanish will be held in print, radio, and television.

Measures of Success: Continuation of a watershed-based Stakeholder Advisory Group where information is disseminated, dialogue, and discussion of issues occurs, and feedback is received to and from the Community.

Deliverables: The following will be submitted with quarterly reports if listed activity occurs within a particular quarter:

- Stakeholder group activities (e.g. announcements, agendas, minutes, or press releases)
- Changes to SAG operating structure
- Changes in SAG membership
- Official acceptance letter(s) from the Stakeholder Group approving the watershed protection plan
- Education and outreach materials developed or utilized
- Attendance at local and regional meetings to communicate and obtain input on the project - describe activities in progress reports

TASK 3: WATER QUALITY MONITORING, BACTERIA SOURCE IDENTIFICATION, DATA COLLECTION, VALIDATION, AND DETERMINATION OF EFFECTIVENESS OF CORRECTIVE MEASURES

Goal: *To (1) further characterize indicator bacteria levels and possible sources pre-implementation and (2) to assess effectiveness of implementation practices.*

Task 3.1 **QAPP –** This project will be conducted under an amended QAPP for Phase I submitted to and previously approved by TCEQ. The QAPP was approved by the stakeholders and draft QAPP provided to TCEQ and EPA on or about December 23, 2008. A planning meeting with TCEQ held approximately 30 days later to discuss their comments on the QAPP. The Final QAPP was approved prior to contract execution.

Task 3.2 **QAPP Amendments and Updates –** QAPP will be revised as necessary for two sampling phases (FY09 and FY11). GRANTEE Project Manager will develop amendments as needed and submit to the TCEQ an updated Quality Assurance Project Plan (QAPP) with project specific data quality objectives consistent with the EPA QA/R5 format 45 days prior to the initiation of any data collection. TCEQ Project Manager will provide comment and approval on the QAPP within 30 days of receipt of the amended QAPP. Updates will on an annual basis if needed according to procedures in the QAPP.

Task 3.3 **Water Quality Monitoring Plan –**
Water Quality Monitoring plan was previously approved by the stakeholders. There are several objectives of the monitoring component of this project. First, it will provide pre- and post-implementation data for ascertaining the effectiveness of BMP measures. Secondly, it strives to further characterize the s (bacteria) through identification of the source of bacterial marker species. This will enhance baseline data and provide comparative data to calculate bacteria load reduction. The data will be used to further characterize the indicator bacteria levels and to determine the impact of multiple BMPs over time at the watershed scale for the Westfield Estates Watershed Protection Plan.

H-GAC monitors two CRP sites immediately upstream and downstream of the watershed inflow into Halls Bayou. Since improvement in the water quality issues post-project may take up to two years to become evident, monitoring through the CRP program after the conclusion of the project is essential. A summary of the CRP results will be provided with annual reports throughout the course of the study and in the Final Report.

Task 3.4 **Data Collection –**
Sampling sites in the watershed and sampling times will correspond to those used in FSSI – Phase I study. Additional sites may be added if necessary.

Task 3.5 **Data Submittal –**
H-GAC will submit the data to TCEQ at the conclusion of each sampling phase in report form. This report will be included in the quarterly report following receipt of data from the laboratory and completion of QAPP audit of the data. TCEQ submission will be before presenting data at Town Meetings.

Ambient data collected quarterly under the CRP program will be submitted pursuant to TCEQ via CRP data reporting requirements. An annual summary will be provided to the TCEQ NPS group.

Measure of Success: Annual updates to the TCEQ and continuing conformance to QAPP provisions.

Deliverables: The following will be submitted with quarterly reports if listed activity occurs within a particular quarter:

- QAPP update and input (annually) – 30 days prior to end of the fiscal year
- Water quality data submittal (CRP) – annual
- Water quality monitoring non-conformances will be included in quarterly progress reports

TASK 4: DETERMININATION OF MANAGEMENT MEASURES

Goal: *Identify and quantify need for correction of specific malfunctioning OSSFs and non-human bacteria water quality issues sources through home surveys, characterization and prioritization of needs, qualification of homes for assistance, and further analysis to identify additional non-human bacteria water quality issues sources.*

Task 4.1 **Survey Community –**
Approximately 700 homes in Westfield Estates will be inspected for status of water use and OSSF issues.

Task4.2 **Malfunctioning OSSF Inspection –**

In-depth inspection and rehabilitation plan development for approximately 5-15% of the homes, estimated to be half of those needing remediation.

Task 4.3 **Prioritization –**
Development of criteria for prioritization of homes in need of corrective action and completing ranking process.

Task 4.4 **Qualification –**
Qualify residents for grant assistance based on need; Develop intake forms, including information on system, health issues of applicant (HIPPA regulations apply); agreements for maintenance and connection to public sanitary system if one becomes available; outreach for participation; collection and review of applicants; and development of action list.

Task 4.5 **Description of needed management measures for specific sites** to be included in the Watershed Protection Plan

Measure of Success: Completion of survey, inspections, prioritization, qualification, and analysis.

Deliverables: The following will be submitted with quarterly reports if listed activity occurs within a particular quarter:

- Inspection criteria for homes
- In-depth inspection and rehabilitation plan for homes
- Criteria for prioritization and qualification
- Prioritization of structural implementation

TASK 5: IMPLEMENTATION OF STRUCTURAL CORRECTIVE MEASURES

Goal: *Implement corrective measures addressing malfunctioning OSSFs to decrease bacterial water quality issues of the bayou*

Task 5.1 **Corrective Maintenance of Certain Systems –**
Addresses water quality issues (bacteria) issues in the Community through pump-out and related maintenance for qualifying systems. Task 5.2 Construction - Remediation, replacement, or installation of OSSFs according to rehabilitation plan, priority, and applicant qualification for homes, or as many homes as funding allows.

Task 5.3 **Maintenance Program-**
Work with partners and homeowners to ensure recipients of maintenance or constructed systems participate in maintenance agreement program.

Measure of Success: Malfunctioning OSSFs returned to useful service or replaced, with participation in a maintenance program.

Deliverable: Updates on the implementation of structural corrective measures will be included in quarterly reports. The following will be submitted with quarterly reports if listed activity occurs within a particular quarter:

- Structural corrective measures implemented
- Corrective maintenance plans
- Construction design of the OSSFs
- Maintenance program plan and agreement for the homeowner

TASK 6: DEVELOPMENT AND IMPLEMENTATION OF BEHAVIORAL MEASURES

Goal: *To reduce bacterial water quality issues resulting from non-human bacterial sources through development and implementation of* BMPs.

Task 6.1 **Develop BMPs –**
With Community involvement, develop BMPs for human and nonhuman sources (dogs, chickens, and other determined sources) contributing to bacterial water quality issues of the watershed.

Task 6.2 **Implementation of BMPs –**
Based on stakeholder and Community resident involvement as part of education and outreach program on OSSF care and maintenance and behavioral modification for watershed activities contributing to non- human source contributions to bacteria levels.

Measure of Success: Development of BMPs and implementation through public outreach meetings.

Deliverable: Activities on the Implementation of Behavioral Measures will be included in the quarterly report. The following will be submitted with quarterly reports if listed activity occurs within a particular quarter:

- BMPs Developed
- Education and outreach materials and activities

TASK 7: EDUCATION AND PUBLIC OUTREACH

Goal: *Develop an information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting,*

designing, and implementing the NPS management measures proposed in the Westfield Estates WPP.

Task 7.1 **Update Westfield Estates WPP-**
Preliminary description of education and outreach efforts included with WPP. These efforts will be expanded as the project moves forward to incorporate specific maintenance aspects necessary for long term success.

Task 7.2 **Education on OSSFs Maintenance and Failure-**
Project promotion and education programs, bilingual in nature where possible. Examples may include manned tables at local businesses (e.g. grocery store), elementary school, faith-based organizations, water bills inserts, fliers, residents going door to door, and town meetings.

Task 7.3 **Continuing Education-**
Education (bilingual) on OSSF care including OSSF brochures, with classes at community center; program transitioned to local stakeholder's advisory group management at end of project.

Task 7.4 **Watershed Protection Plan Website –**
Updates of Westfield Estates WPP on H-GAC's Watershed Protection Plan web page. To include maps; Phase I report; meeting information, notes and agenda; survey; and regular status updates on the implementation phase and WWP itself. (http://h-gac.com/westfield)

Task 7.5 **Education on Behavioral BMPs**
Project promotion and education programs, bilingual in nature where possible. Examples may include manned tables at local businesses (e.g. grocery store), elementary school, faith-based organizations, water bills inserts, fliers, residents going door to door, and town meetings.

Measure of Success: Description of education and outreach in WPP, development of educational material, public participation in town meetings and continuing education classes and inclusion of WPP update on H-GAC's webpage.

Deliverable: Education and public outreach activities will be included in the quarterly report. The following will be submitted with quarterly reports if listed activity occurs within a particular quarter:

- Education and outreach materials
- Webpage Updates

TASK 8: WATERSHED PROTECTION PLAN UPDATE

Goal: *Update the Westfield Estates WPP as it addresses bacterial water quality issues in the Westfield Estates Watershed.*

Task 8.1: **Update Plan –**
The Westfield Estates WPP was completed prior to contract execution. Updates based on information collected under this project, including stakeholder-based input, will be provided as the need arises. Finalizing the Permanent Stakeholder Advisory Group, which will take responsibility for maintaining the plan, will not occur until the project "wrap-up meeting.

Measure of Success: Plan updated as needed

Deliverable: Activities for the quarter on the watershed protection plan updates will be included in the quarterly report. The following will be submitted with quarterly reports if listed activity occurs within a particular quarter:

- Westfield Estates WPP updated as needed

TASK 9: INDICATORS TO MEASURE PROGRESS, AND EFFECTIVENESS OF IMPLEMENTATION EFFORTS POST-CONSTRUCTION

Goal: *To determine the effectiveness of remediation of a significant number of malfunctioning OSSFs in a community on reducing bacterial water quality issues in the bayou.*

Task 9.1 **Pre- and Post-construction Monitoring –**
Monitor selected sites in the watershed for in accordance with sites and protocols in the QAPP.

Task 9.2 **Survey Septic Violations –**
Determine level of OSSF failure violations in Community pre- and post-construction.

Task 9.3 **Quantify Water Quality Issue Reduction-**
Determine decrease of nonhuman bacterial sources in watershed by indicator bacterial level reduction and bacteria source tracking.

Task 9.4 **Continuing Maintenance-**
Maintenance of OSSFs through arrangement with stakeholder partner FWSD and monitored by SAG until transfer to the permanent stakeholder's advisory group.

Measure of Success: Collection and review of sampling data to assess success of malfunctioning OSSF corrective measures on reducing bacterial water quality issues in the bayou. Inclusion of data in the final report.

Deliverable: The following will be submitted with quarterly reports if listed activity occurs within a particular quarter:

- Monitoring, data collection, and analysis pre- and post- implementation
- OSSFs maintenance agreements

TASK 10: FINAL REPORT

Goal: *To provide the TCEQ and the EPA with a comprehensive report on the activities and success of the pilot project conducted by the Grantee Organization during the course of this project.*

Task 10.1 **Draft Final Report –**
Provide a comprehensive, technical report summarizing all project activities, findings, and the contents of all previous deliverables, referencing and/or attaching them as web links or appendices. This comprehensive, technical report will provide analysis of all activities and deliverables under this scope of work. The report may include the following information in acceptable format:

Title
Table of Contents
Executive Summary
Introduction
Project Significance and Background
Methods
Results and Observations
Discussion
Summary
References
Appendices

TCEQ Project Manager will review this report within 30 days of receipt and provide comment.

Task 10.2 **Final Report –**
Revise the Draft report to address comments provided by the TCEQ Project Manager.

Measure of Success: Acceptance of the report by the TCEQ.

Deliverables:

- Final Draft Report– 7/15/2011
- Final Report- 8/31/2011

D.2 Deliverable Due Dates

Schedule of Deliverables Based on Project Funding/Initiation of February 17, 2009. Schedule and Scope of Work will be amended accordingly if Project Funding/Initiation is delayed.

Table D.2.1 – Deliverable Due Dates

Task No.	Deliverable	Due Date
	Post Award Meeting	To Be Determined
1.2	Quarter Three Progress Report FY 09	6/15/09
1.2	Quarter Four Progress Report FY 09	9/15/09
1.2	Quarter One Progress Report FY 10	12/15/09
1.2	Quarter Two Progress Report FY 10	3/15/10
1.2	Quarter Three Progress Report FY 10	6/15/10
1.2	Quarter Four Progress Report FY 10	9/15/10
1.2	Quarter One Progress Report FY 11	12/15/10
1.2	Quarter Two Progress Report FY 11	3/15/11
1.2	Quarter Three Progress Report FY 11	6/15/11
1.2	Quarter Four Progress Report FY 11	8/31/11
1.3	Quarter Two Reimbursement Request FY 09	3/31/09
1.3	Quarter Three Reimbursement Request FY 09	6/30/09
1.3	Quarter Four Reimbursement Request FY 09	9/30/09
1.3	Quarter One Reimbursement Request FY 10	12/31/09
1.3	Quarter Two Reimbursement Request FY 10	3/31/10
1.3	Quarter Three Reimbursement Request FY 10	6/30/10
1.3	Quarter Four Reimbursement Request FY 10	9/30/10
1.3	Quarter One Reimbursement Request FY 11	12/31/10
1.3	Quarter Two Reimbursement Request FY 11	3/31/11
1.3	Quarter Three Reimbursement Request FY 11	6/30/11
1.3	Quarter Four Reimbursement Request FY 11	9/15/11
1.4	Quarterly conference call with TCEQ	4/15/2009
1.4	Quarterly conference call with TCEQ	7/15/2009
1.4	Quarterly conference call with TCEQ	10/15/2009
1.4	Quarterly conference call with TCEQ	1/15/2010
1.4	Quarterly conference call with TCEQ	4/15/2010
1.4	Quarterly conference call with TCEQ	7/15/2010
1.4	Quarterly conference call with TCEQ	10/15/2010
1.4	Quarterly conference call with TCEQ	1/15/2011
1.4	Quarterly conference call with TCEQ	4/15/2011
1.4	Contractor Self-Evaluation	8/31/09
1.5	Quarterly conference call with TCEQ	7/15/2011
1.5	Contractor Self-Evaluation	8/31/10
1.5	Contractor Self-Evaluation	8/31/11
1.6	Project Fact Sheet	60 days after receipt

		of template after contract initiation
1.6	Project Fact Sheet Update	8/31/09
1.6	Project Fact Sheet Update	8/31/10
1.6	Project Fact Sheet Update	8/31/11
10.1	Draft Final Report	7/15/11
7.2, 10.2	Final Report	8/31/11

A summary of the proposed budget for the project is shown below. A detailed budget is available upon request.

Table D.2.2 Budget Overview FY09-FY11

Budget Categories	**Year 1 – FY09 2/2/09-8/31/09**	**Year 2 – FY10 9/1/09-8/31/10**	**Year 3 – FY11 9/1/10-8/31/11**	**FY09-FY11 Total**
a. Personnel/Salary	30,912.00	45,486.00	46,850.00	123,248.00
b. Fringe Benefits	13,168.51	19,377.04	19,958.10	52,503.65
c. Travel	2,109.00	1,782.00	2,109.00	6,000.00
d. Supplies	9,867.00	667.00	5,667.00	16,201.00
e. Equipment	10,000.00	-	-	10,000.00
f. Contractual (Construction)	90,096.00	300,000.00	65,000.00	455,096.00
g. Construction	-	-	-	-
h. Other	15,110.00	12,949.00	17,948.00	46,007.00
i. Other In-kind contributions	136,000.00	238,350.00	112,650.00	487,000.00
j. Total Direct Costs (sum a-i)	307,262.51	618,611.04	270,182.10	1,196,055.65
k. Indirect costs	5,378.69	7,914.56	8,151.90	21,445.15
l. Total Costs (Sum of j & k)	312,641.20	626,525.60	278,334.00	1,217,500.80
m. Recipient Cost Share (40%)	125,056.48	250,610.24	111,333.60	487,000.32
a. Personnel/Salary	187,584.72	375,915.36	167,000.40	730,500.48