Watersheds Upstream of Lake Houston: Bacteria in Waters Used for Contact Recreation

- **Fifteen TMDLs Adopted April 6, 2011**
  Approved by EPA June 29, 2011

- **Six TMDLs Added by Addendum October 2013**
  Approved by EPA February 14, 2014 (scroll to view or print this addendum)

Prepared by the:
TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Addendum One to Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston

Six Additional Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston

For Segments 1008B, 1008C, 1008E, and 1011
Assessment Units 1008B_01, 1008B_02, 1008C _01, 1008C_02, 1008E_01, and 1011_01

Introduction

The Texas Commission on Environmental Quality (TCEQ) adopted the total maximum daily loads (TMDLs) *Fifteen Total Maximum Daily Loads for Indicator Bacteria in Watersheds Upstream of Lake Houston: Segments 1004E, 1008, 1008H, 1009, 1009C, 1009D, 1009E, 1010 and 1011* (TCEQ 2011) on 4/6/2011. The TMDLs were approved by the United States Environmental Protection Agency (EPA) on 6/29/2011. This document represents an addendum to the original TMDL document.

This addendum includes information specific to six additional assessment units (AUs) located within four segments of the approved TMDL project for bacteria in the watersheds upstream of Lake Houston. Concentrations of indicator bacteria in these AUs exceed the criteria used to evaluate attainment of the contact recreation standard. This addendum presents the new information associated with the six additional AUs. For background or other explanatory information for these six AUs and four segments, please refer to *Technical Support Document: Total Maximum Daily Loads for Indicator Bacteria in Upper & Lower Panther Branch, Bear Branch and Peach Creek Watersheds: Segments 1008B, 1008C, 1008E, and 1011* (Millican et al. 2013), which has additional details related to all aspects of this addendum.

Refer to the original, approved TMDL document for details related to the overall project watershed as well as the methods and assumptions used in developing all of these TMDLs. This addendum focuses on the subwatersheds of the additional AUs. These subwatersheds, including permitted facilities within them, were addressed in the original TMDL. This addendum provides the details related to developing the TMDL allocations for these additional AUs, which were not addressed individually in the original document. These segments and AUs are also covered by an implementation plan (I-Plan) that has been approved by TCEQ for the greater Houston area (H-GAC and BIG 2013). The I-Plan addresses multiple watersheds, including these watersheds upstream of Lake Houston.

Problem Definition

The TCEQ first identified the bacteria impairments to the segments and AUs of Upper Panther Branch and Peach Creek, which are included in this addendum, in the year 2006 Texas Water Quality Inventory and 303(d) List. Bacteria impairments for Lower Panther Branch and Bear Branch, which are also included in this addendum, were first identified in the 2010 Texas Water Quality Inventory and 303(d) List (Table 1). The impaired AUs are Upper Panther Branch (1008B_01 and 1008B_02), Lower Panther Branch (1008C_01 and 1008C_02), Bear Branch (1008E_01), and Peach Creek (1011_01). See Figure 1 for a map of the watershed.

The Texas surface water quality standards (SWQS; TCEQ 2010) provide numeric and narrative criteria to evaluate attainment of designated uses. The basis for water quality targets for all TMDLs developed in this report will be the numeric criteria for bacterial indicators from the 2010 Texas SWQS. *Escherichia coli* (*E. coli*) are the preferred indicator bacteria for assessing contact recreation use in freshwater.

Table 2 summarizes the ambient water quality data for the TCEQ water quality monitoring (WQM) stations on each impaired water body as reported in *the 2012 Texas Integrated Report* (TCEQ 2013). The 2012 assessment data indicate non-support of the primary contact recreation use because the geometric mean concentrations exceed the geometric mean criterion of 126 most probable number (MPN)/100 milliliters (mL) for the six addendum AUs within the Upper and Lower Panther Branch, Bear Branch, and Peach Creek study areas.

Watershed Overview

The total drainage area for Lake Houston is 2,850 square miles. The TMDL watersheds are located primarily within Montgomery and San Jacinto Counties, but also include portions of Walker and Liberty Counties (Figure 1). Upper Panther Branch (Segment 1008B) begins at Old Conroe Road and continues to the confluence with Lake Woodlands, draining approximately 12 square miles. Lower Panther Branch (Segment 1008C) flows south from Lake Woodlands Dam to the confluence with Spring Creek and drains approximately eight square miles. Bear Branch (Segment 1008E) lies to the west of Upper Panther Branch and flows southeasterly from FM 1488 to the confluence with Upper Panther Branch and drains approximately 16 square miles. These three segments are entirely located in Montgomery County, Texas. To the east, Peach Creek (Segment 1011) serves as the boundary between San Jacinto and Montgomery Counties. It flows southeasterly from SH 150 in Walker County to the confluence with Caney Creek in Montgomery County. Peach Creek drains approximately 135 square miles in Walker, San Jacinto, Montgomery, and Liberty Counties. Much of Peach Creek's northern half is located inside the Sam Houston National Forest.

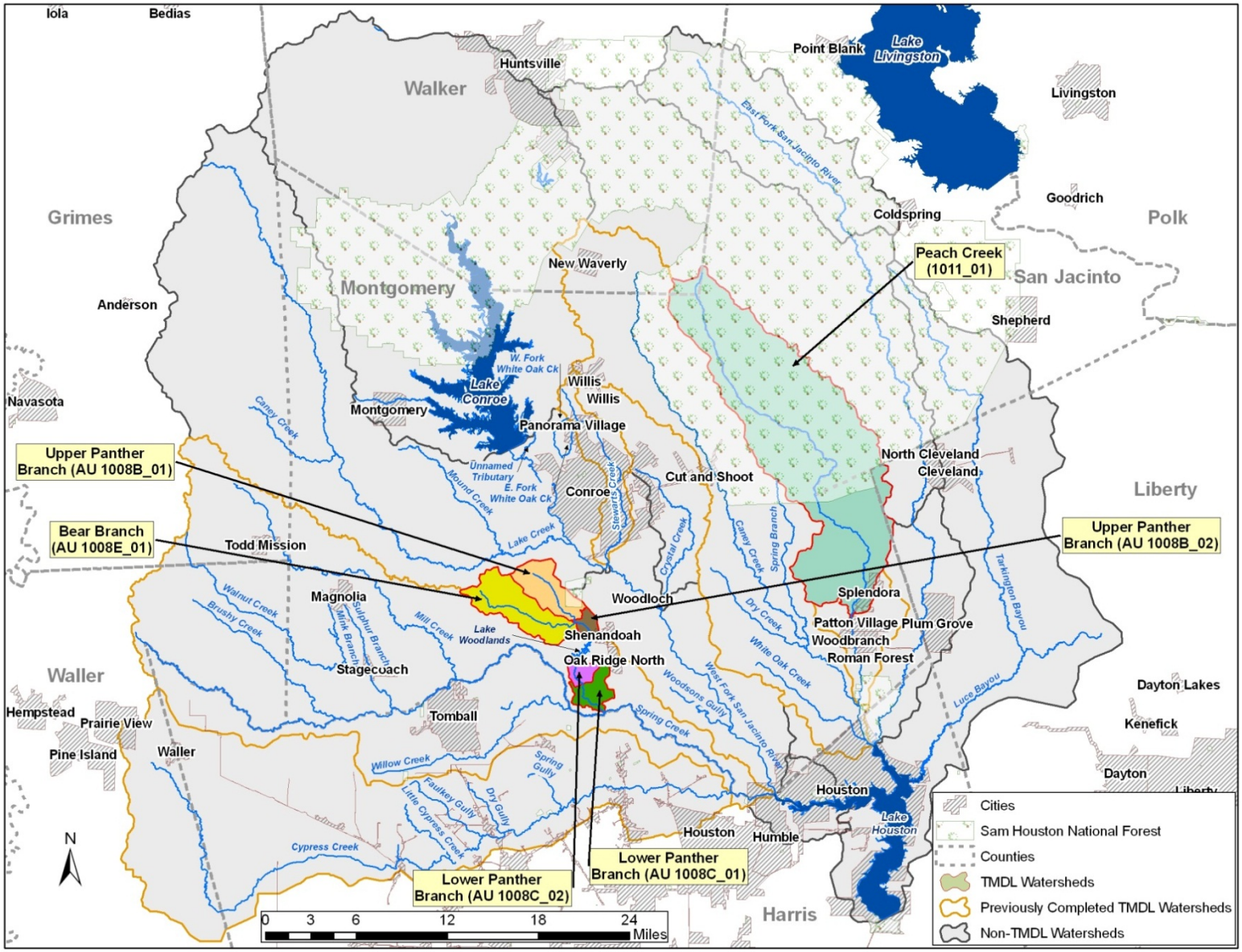

Figure1. Watersheds above Lake Houston, Including Segments 1008B, 1008C, 1008E, and 1011

Table 1. Synopsis of Texas Integrated Report for Addendum Water Bodies in the Watersheds of Lake Houston

Segment ID	Segment Name	Parameter	Contact Recreation Use	Year Impaired	Category
1008B	Upper Panther Branch	*E. coli*	Nonsupport	2006	5a
1008C	Lower Panther Branch	*E. coli*	Nonsupport	2010	5a
1008E	Bear Branch	*E. coli*	Nonsupport	2010	5a
1011	Peach Creek	*E. coli*	Nonsupport	2006	5a

Table 2. 2012 Integrated Report Summary for the Subwatersheds of Upper and Lower Panther Branch, Bear Branch, and Peach Creek

(Source: TCEQ 2013)

Water Body	Assessment Unit (AU)	2012 Assessment No. of Samples	2012 Assessment Geometric Mean (MPN/100 mL)
Upper Panther Branch	1008B_01	28	158
Upper Panther Branch	1008B_02	28	246
Lower Panther Branch	1008C_01	28	198
Lower Panther Branch	1008C_02	28	157
Bear Branch	1008E_01	27	167
Peach Creek	1011_01	43	162

MPN: Most Probable Number

Geometric Mean Criterion: 126 MPN/100 m.

The 2012 *Texas Integrated Report* (TCEQ 2013) provides the following segment and AU descriptions for the water bodies considered in this document:

- Segment 1008B (Upper Panther Branch (unclassified water body)) – From the normal pool elevation of 125 feet of Lake Woodlands upstream to Old Conroe Road.
  - 1008B_01 – From Old Conroe Road to a point 0.22 miles (0.35 km) upstream of the Bear Branch confluence.
  - 1008B_02 – From a point 0.22 miles (0.35 km) upstream of the Bear Branch confluence to the confluence of Lake Woodlands.
- Segment 1008C (Lower Panther Branch (unclassified water body)) – From the Spring Creek confluence upstream to the dam impounding Lake Woodlands in Montgomery County.
  - 1008C_01 – From Spring Creek confluence upstream to Saw Dust Road.
  - 1008C_02 – From Saw Dust Road to the Lake Woodlands Dam.
- Segment 1008E (Bear Branch (unclassified water body)) – From the Upper Panther Branch confluence to south of FM1488 in Montgomery County.
  - 1008E_01 – From Upper Panther Branch confluence to south of FM 1488.

- Segment 1011 (Peach Creek) – From the confluence with Caney Creek in Montgomery County to SH 150 in Walker County.
    - 1011_01 – Upper segment boundary to US Hwy 59.

The Lake Houston watershed is within the Upper Coast and East Texas climatic divisions. The Gulf of Mexico is the principal source of moisture that drives precipitation in the region. Annual average precipitation generally increases from west to east across the watershed. Annual average precipitation data (1997-2006) for key weather stations is provided in Table 3. These data were obtained through the USEPA BASINS program (USEPA 2007). In 2007, the annual precipitation totals at Tomball, Conroe, and George Bush Intercontinental Airport were 53.2, 50.5, and 65.5 inches, respectively (NWS 2008).

Table 3. Average Annual Precipitation for Watersheds above Lake Houston, 1997-2006 (in inches)

Station ID	Location	Average (in.)
TX411810	Cleveland	57.2
TX411956	Conroe	51.1
TX412206	Cypress	50.2
TX414300	George Bush Intercontinental Airport	53.1
TX416024	Montgomery	47.7
TX416280	New Caney	55.4
TX419076	Tomball	51.3
	Overall Average	**52.3**

Table 4 summarizes the acreages and the corresponding percentages of the land use categories associated with the six impaired AUs included in this addendum. The land use/land cover data were obtained from the 2008 Houston-Galveston Area Council (H-GAC) land cover dataset (H-GAC 2008). Assessment units 1008B_01, 1008B_02, 1008C_01, 1008C_02, and 1008E_01 are primarily developed except for the northern half of 1008B_01 which is forested. The upstream portion of Peach Creek watershed (1011_01) is largely in the Sam Houston National Forest. Thus AU 1101_01 contains only 7% developed and cultivated land while forest, shrubland, and wetlands, account for the remaining 93% of land cover. The total acreage of each AU in Table 4 corresponds to the watershed delineation in Figure 2.

Population estimates and future population projections were examined for each segment and AU in the project area. These are discussed in the original TMDL document as well as the technical support document for this addendum.

Endpoint Identification

The water quality target for the TMDLs for these freshwater segments is to maintain concentrations below the geometric mean criterion of 126 MPN/100 mL for *E. coli*. The TMDLs will be based on bacteria allocations required to meet the geometric mean criterion.

Table 4. Aggregated Land Use Summaries by Impaired AUs

(Source: H-GAC, 2008)

Land Use Category	1008B_01	1008B_02	1008C_01	1008C_02	1008E_01	1011_01
Acres Developed, High Intensity	916.7	309.4	833.6	376.5	1,808.0	2,400.0
Acres Developed, Low Intensity	1,753.6	437.3	1,464.5	771.8	4,522.8	2,004.6
Acres Developed, Open Space	3.7	1.6	75.9	137.8	291.3	68.8
Acres Cultivated	64.7	0.0	0.6	0.0	57.7	1373.5
Acres Grassland/Shrub	1,029.1	326.8	163.1	56.3	1,578.7	20,142.4
Acres Forest	2,107.0	255.0	287.1	113.4	1,041.1	48,195.0
Acres Woody Wetland	224.7	264.0	330.5	125.3	647.6	1,0675.3
Acres Herbaceous Wetland	3.8	7.9	0.8	0.0	12.3	41.7
Acres Bare	16.2	0.0	0.0	0.0	0.9	1484.9
Acres Open Water	41.4	19.6	32.3	32.4	145.6	215.1
Watershed Area (acres)	**6,160.9**	**1,621.4**	**3,188.5**	**1,613.4**	**10,106.0**	**86,601.4**
Percent Developed, High Intensity	14.9%	19.1%	26.1%	23.3%	17.9%	2.8%
Percent Developed, Low Intensity	28.5%	27.0%	45.9%	47.8%	44.8%	2.3%
Percent Developed, Open Space	0.1%	0.1%	2.4%	8.5%	2.9%	0.1%
Percent Cultivated	1.1%	0.0%	0.0%	0.0%	0.6%	1.6%
Percent Grassland/Shrub	16.7%	20.2%	5.1%	3.5%	15.6%	23.3%
Percent Forest	34.2%	15.7%	9.0%	7.0%	10.3%	55.7%
Percent Woody Wetland	3.6%	16.3%	10.4%	7.8%	6.4%	12.3%
Percent Herbaceous Wetland	0.1%	0.5%	0.0%	0.0%	0.1%	0.0%
Percent Bare	0.3%	0.0%	0.0%	0.0%	0.0%	1.7%
Percent Open Water	0.7%	1.2%	1.0%	2.0%	1.4%	0.2%

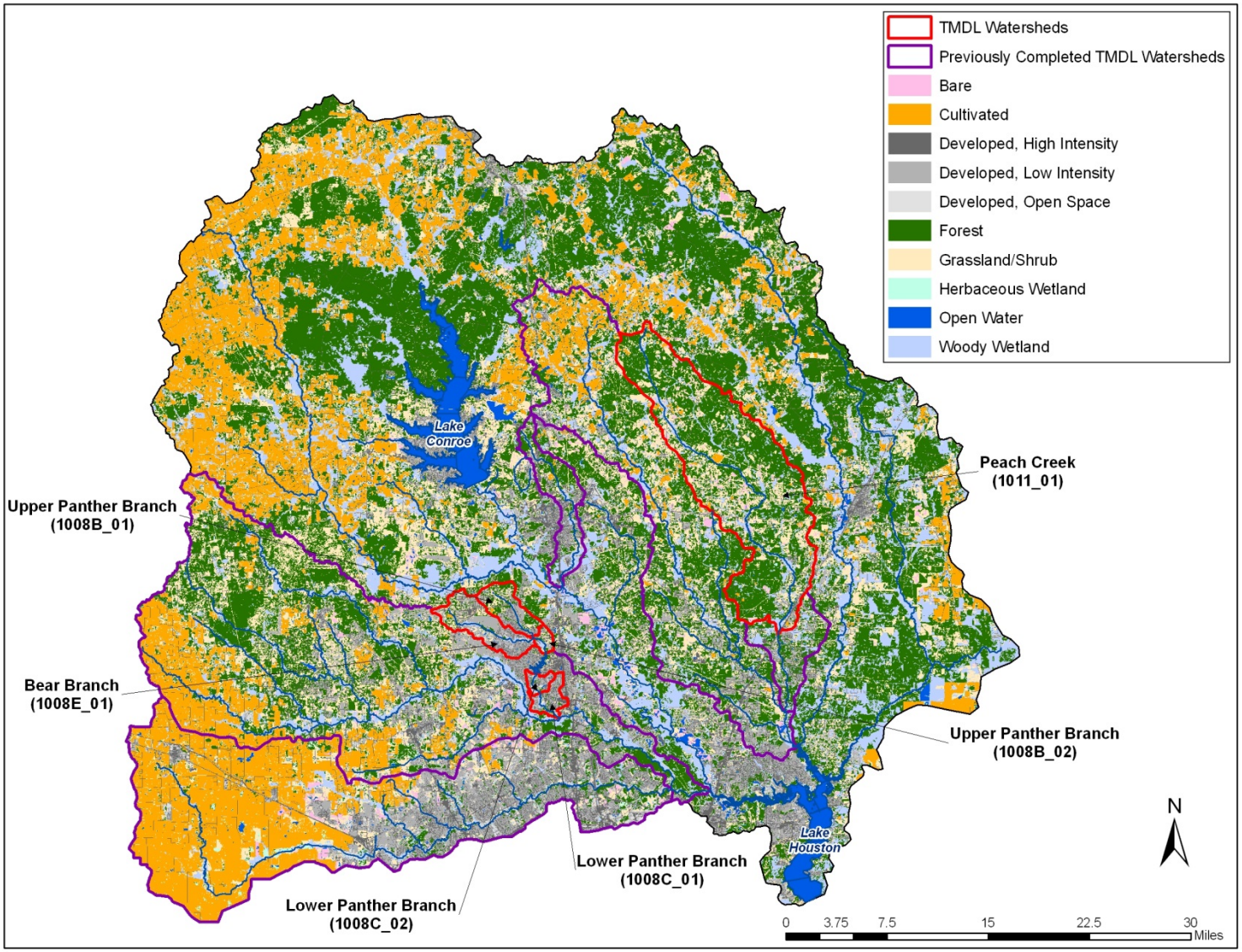

Figure 2. Land Use/Land Cover in the Watersheds above Lake Houston
(Source: H-GAC, 2008)

Source Analysis

Regulated Sources

There are 11 National Pollutant Discharge Elimination System (NPDES)/Texas Pollutant Discharge Elimination System (TPDES)-permitted facilities within the project's subwatersheds. The 11 TPDES-permitted facilities that continuously discharge wastewater to surface waters addressed in these TMDLs are listed in Table 5 and shown in Figures 3 and 4.

Table 5. NPDES and TPDES-Permitted Facilities in the Impaired AUs

AU	Receiving Water Segment	TPDES Number	NPDES NUMBER	Facility Name	Effluent Type[a]	Permitted Flow (MGD)
1008B_01	Upper Panther Branch	12597-001	TX0091715	The Woodlands WWTP 2	WW	7.800
1008C_02	Lower Panther Branch	11401-001[b]	TX0054186	Woodlands	WW	7.800
1008C_01	Lower Panther Branch	13697-001	TX0090000	Cedarstone WWTP	WW	0.003
1008E_01	Bear Branch	14141-001	TX0120073	Old Egypt Regional Business Center	WW	0.450
1008E_01	Bear Branch	14918-001	TX0131725	Eaglestar WWTP	WW	0.100
1008E_01	Bear Branch	14909-001	TX0131652	Lincoln Manufacturing	WW	0.050
1008E_01	Bear Branch	14013-001	TX0118028	Greenfield Forest WWTP	WW	0.050
1008E_01	Bear Branch	12703-001	TX0092843	Bear Branch Plant	WW	0.048
1011_01	Peach Creek	13389-001	TX0102512	City of Splendora WWTP	WW	0.300
1011_01	Peach Creek	11143-001	TX0082511	Splendora Elementary School	WW	0.040
1011_01	Peach Creek	11143-002	TX0117463	Splendora ISD WWTP	WW	0.040

[a] *WW = domestic wastewater treatment facility*

[b] *Represents the two outfalls at this facility. Pipe #2 in operation since Nov. 2007. (Both locations shown in southeast portion of Figure 3)*

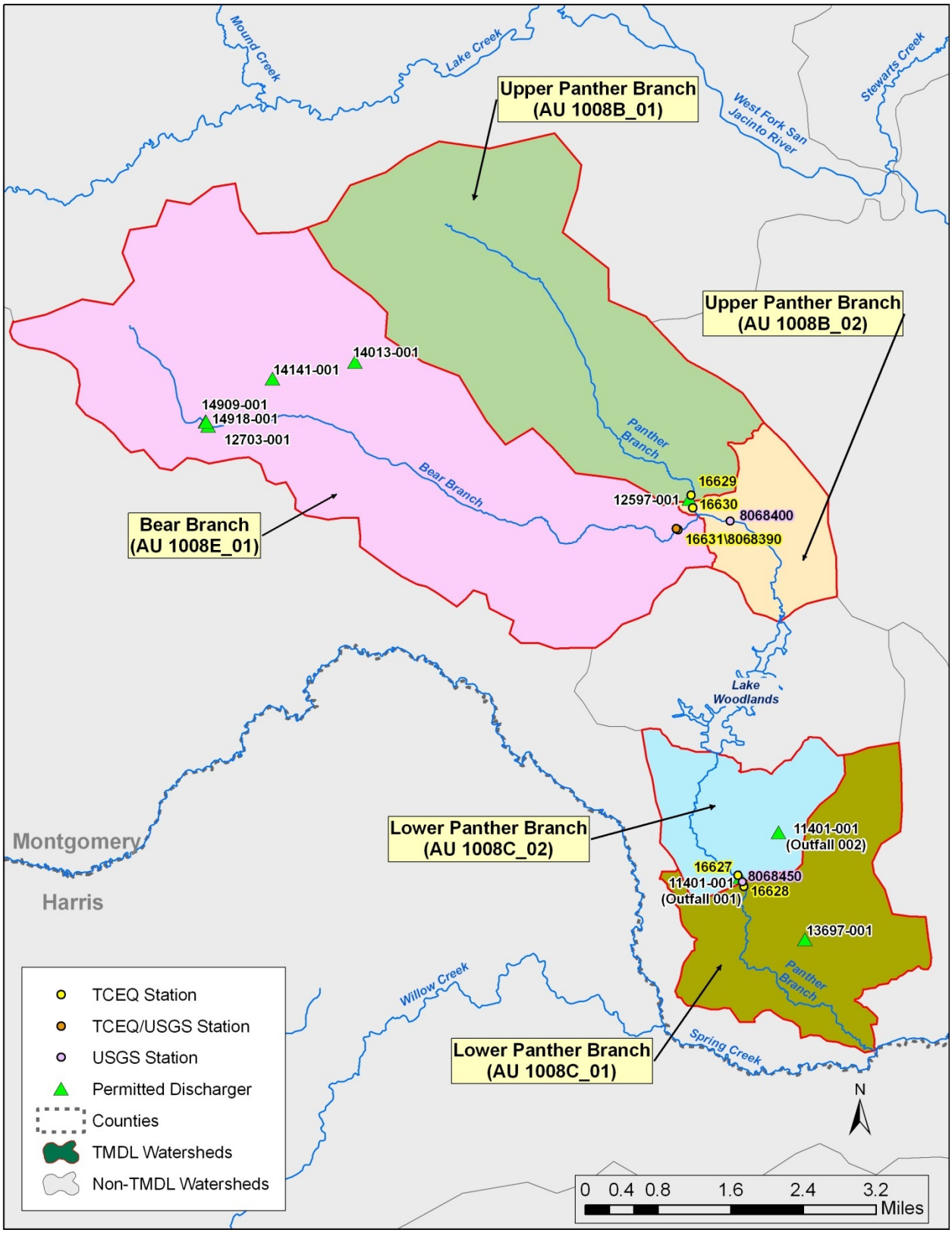

Figure 3. Upper and Lower Panther Branch, and Bear Branch Subwatersheds Showing Permitted Dischargers, WQM stations, and USGS stations

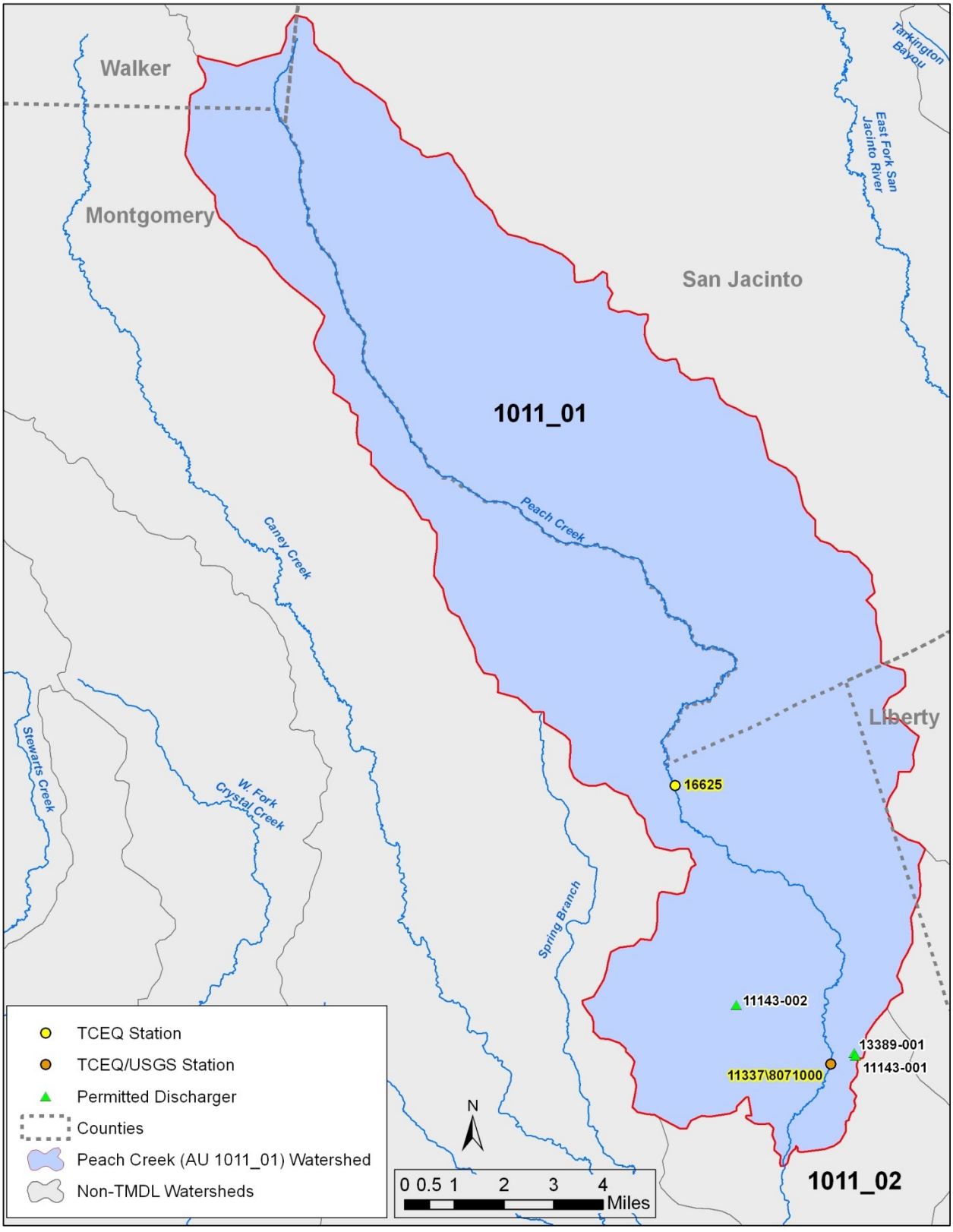

Figure 4. Peach Creek Subwatershed Showing Permitted dischargers, WQM Stations and USGS Station

Sanitary Sewer Overflows

Sanitary sewer overflows (SSOs) are unauthorized discharges that must be addressed by the responsible party. The TCEQ Region 12 Office maintains a database of SSO data reported by municipalities. This SSO data typically contains an estimate of the total gallons spilled, responsible entity, and a general location of the spill. The dataset covers late 2001 - January 2013, and no SSOs were reported for the areas covered by the permits in the Upper and Lower Panther Branch, Bear Branch, and Peach Creek watersheds.

TPDES-Regulated Stormwater

Portions of the six impaired AUs are regulated under Phase II municipal separate storm sewer system (MS4) permits. The process for renewal of the Texas general permit for Phase II MS4s was ongoing at the time of this addendum. The proposed language for the general permit renewal bases the Phase II permittees jurisdictional areas on the larger of the 2000 and 2010 Urbanized Areas.

The 2010 Urbanized Area is used to represent the areas under stormwater regulation for construction, industrial, and Phase II MS4 permits (Figure 5; USCB 2010). The impaired AU watersheds contain entities that are regulated under Phase II general permits and no Phase I entities (Table 6). Using the 2010 Urbanized Area as the basis of computation, the percentage of land area under the jurisdiction of stormwater permits for each of the TMDL watersheds is presented in Table 7.

Table 6. TPDES MS4 Permits Associated with Impaired AU Subwatersheds

Entity	Permit Number	AU
The Woodlands Joint Powers Agency MS4	TXR040256	1008B_01, 1008B_02, 1008C_01, 1008C_02, 1008E_01
Montgomery County MS4	TXR040348	1008B_01, 1008B_02, 1008C_01, 1008C_02, 1008E_01, 1011_01
City of Shenandoah MS4	TXR040210	1008B_02
City of Oak Ridge North MS4	TXR040273	1008C_01
Southern Montgomery County MUD MS4	TXR040122	1008C_01
Montgomery County MUD 19 MS4	TXR040123	1008C_01

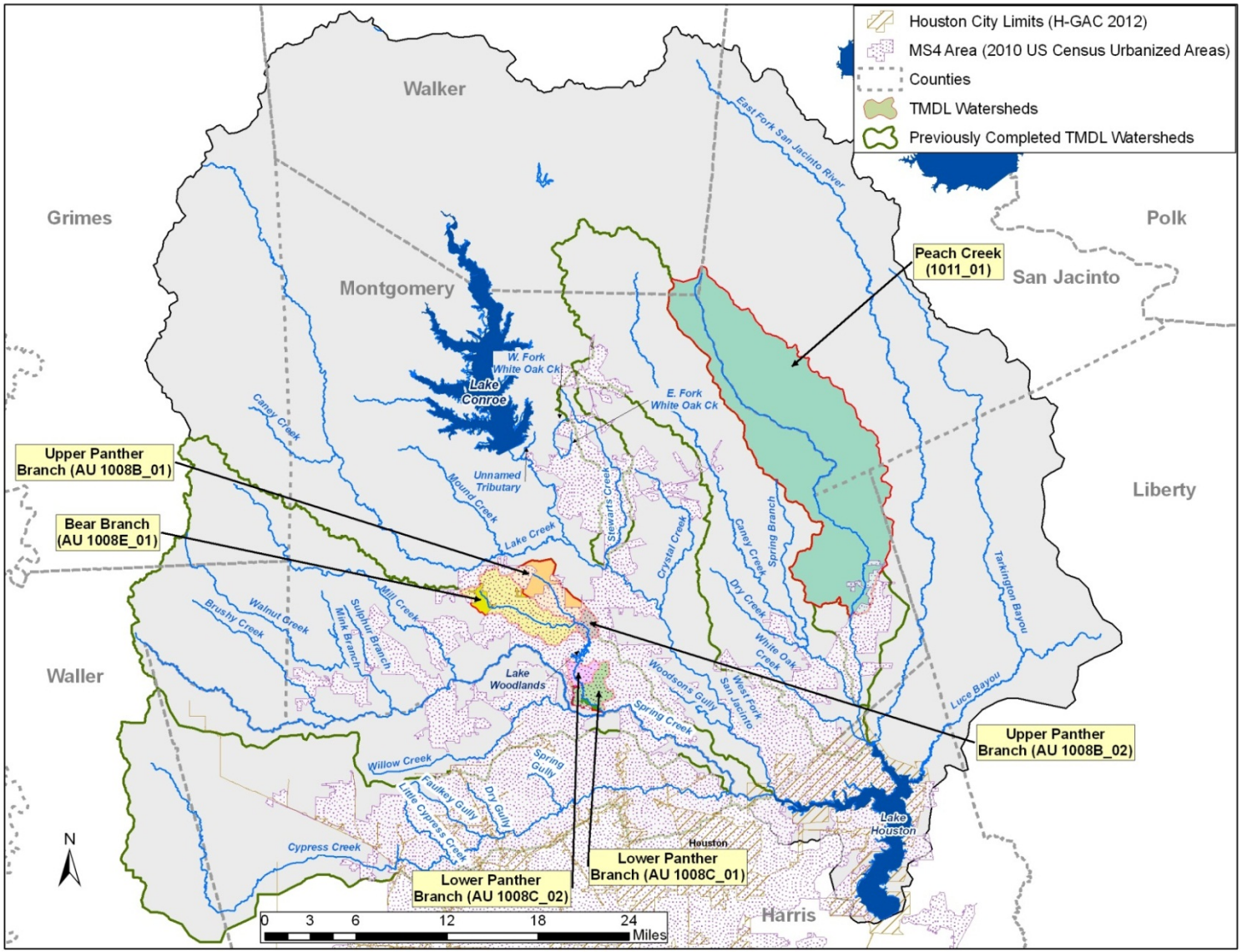

Figure 5. Upper and Lower Panther Branch, Bear Branch, and Peach Creek Subwatersheds Showing 2010 Urbanized Areas
(Source: USCB 2010 & H-GAC 2012)

Table 7. Estimated Area under Stormwater Permit Regulations for Impaired AU Subwatersheds

AU	AU Area within 2010 Urbanized Areas (ha)	AU watershed area (ha)	Percentage of drainage area under stormwater regulation (%)
1008B_01	3,763	6,406	58.7
1008B_02	1,377	1,377	100.0
1008C_01	2,897	3,188	90.8
1008C_02	1,598	1,613	99.0
1008E_01	9,028	10,106	89.3
1011_01	1,312	86,601	1.51

ha: hectare

Unregulated Sources

Pollutants from unregulated sources enter the impaired AUs through distributed, nonspecific locations, which may include urban runoff not covered by a permit, wildlife, various agricultural activities and animals, land application fields, failing onsite sewage facilities (OSSFs), and domestic pets.

Wildlife and Unmanaged Animal Contributions

Currently there are insufficient data available to estimate populations and spatial distribution of wildlife and avian species by subwatershed. Consequently, it is difficult to assess the magnitude of bacteria contributions from wildlife species as a general category.

Unregulated Agricultural Activities and Domesticated Animals

The number of livestock that are found within the impaired AU watersheds was estimated from county-level data obtained from the 2007 Census of Agriculture (USDA 2007). The county-level data were refined to better reflect actual numbers within each impaired AU subwatershed. The refinement was performed by determining the total area of each county and each impaired AU that was designated as un-urbanized by the 2010 U.S. Census. A ratio was then developed by dividing the un-urbanized area of the AU that exists within a county by the total un-urbanized area of the county. This ratio was then applied to the county-level data. Activities, such as livestock grazing close to water bodies and farmers' use of manure as fertilizer, can contribute *E. coli* to nearby water bodies. The livestock numbers in Table 8 are provided to demonstrate that livestock are a potential source of bacteria in the watersheds of AU1008B_01 and AU 1011_01, but less likely a significant source in the other watersheds. These livestock numbers, however, are not used to develop an allocation of allowable bacteria loading to livestock.

Table 8. Livestock statistics Estimates for Upper and Lower Panther Branch, Bear Branch, and Peach Creek Subwatersheds

(Estimated livestock numbers less than 10 reported as <10; estimates based on data from USDA 2007)

AU	Cattles and Calves	Hogs and Pigs	Chickens	Other Poultry	Horses and Ponies	Sheep and Goats
1008B_01	399	10	136	14	109	53
1008B_02	<10	<10	<10	<10	<10	<10
1008C_01	10	<10	<10	<10	<10	<10
1008C_02	<10	<10	<10	<10	<10	<10
1008E_01	49	<10	17	<10	13	<10
1011_01	3911	106	572	64	160	157

Failing Onsite Sewage Facilities

Estimates of the number of OSSFs in the Lake Houston watershed were determined using H-GAC-supplied data and 911 address information for Grimes and San Jacinto Counties, which are outside the 13-county region of the H-GAC. For Harris and Montgomery Counties, the H-GAC data included registered OSSFs since 1970, and for Walker, Waller, and Liberty Counties the registration of facilities began in 1989. Further, H-GAC-supplied data included estimated OSSF locations that pre-dated registration requirements. For Grimes and San Jacinto Counties, the approach to estimate OSSFs was to obtain a GIS layer of the 911 addresses from each county, limit the area considered to that portion of each county in the Lake Houston watershed, and exclude all addresses that were not designated residential or business. The TCEQ GIS layer of Certificates of Convenience and Necessity (CCN) and the H-GAC Service Area Boundaries (SAB) layer for wastewater service were then overlain and all 911 addresses within a CCN or SAB area were assumed to be on a centralized wastewater collection system. Each remaining 911 address was assumed to have an OSSF. Estimated densities of OSSFs are provided in Figure 6, and an estimate of the number of OSSFs in each AU of the addendum TMDL watersheds is provided in Table 9.

Table 9. OSSF estimates for Addendum TMDL Subwatersheds by AU

AU	OSSFs
1008B_01	785
1008B_02	86
1008C_01	6
1008C_02	22
1008E_01	1,474
1011_01	2,880

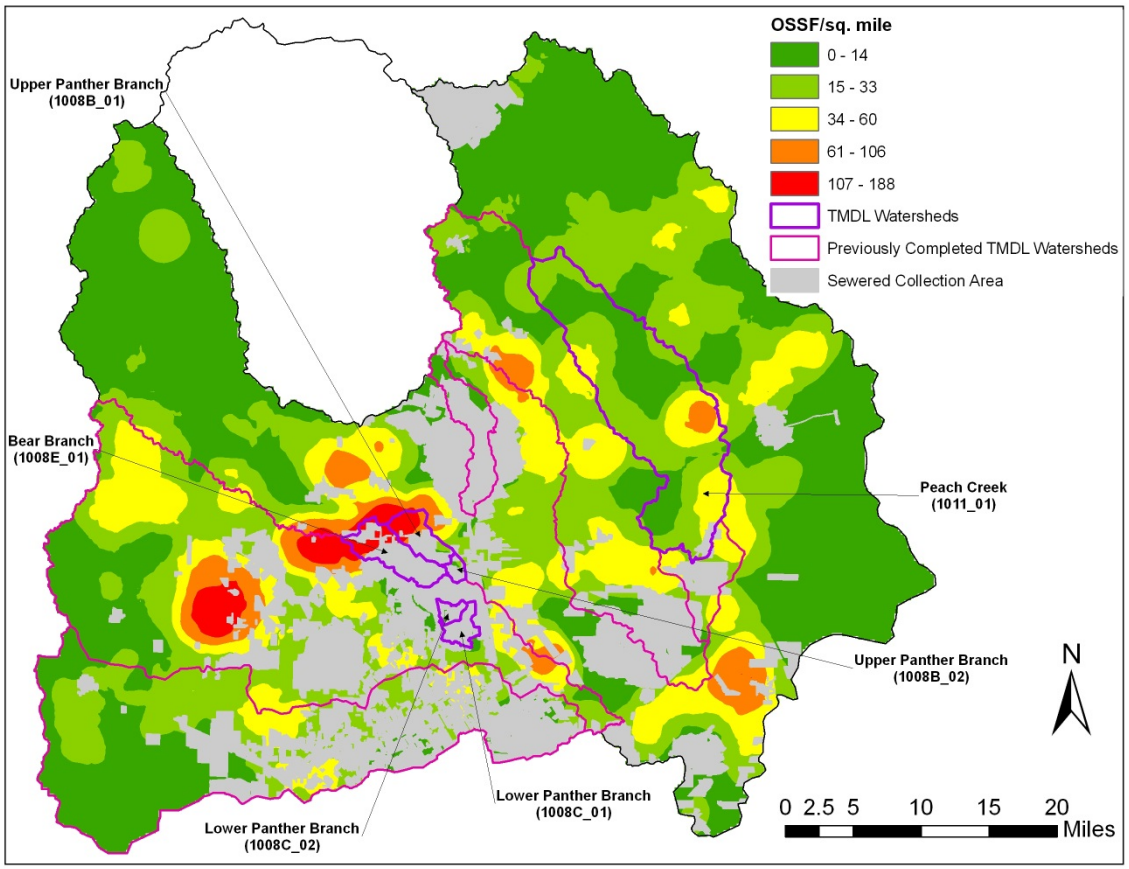

Figure 6. OSSF Densities within Watersheds above Lake Houston

Domestic Pets

Fecal matter from dogs and cats is transported to streams by runoff in both urban and rural areas and can be a potential source of bacteria loading. Table 10 summarizes the estimated number of dogs and cats for each segment of the TMDL subwatersheds addressed by this addendum. Pet population estimates were calculated as the estimated number of dogs (0.584) and cats (0.632) per household (AVMA 2012). The actual contribution and significance of fecal coliform loads from pets reaching the water bodies of the impaired AU watersheds is unknown.

Table 10. Estimated Households and Pet Populations within Impaired AU Subwatersheds

AU	Estimated Number of Households	Estimated Dog Population	Estimated Cat Population
1008B_01	4,154	2,426	2,625
1008B_02	930	543	588
1008C_01	6,708	3,917	4,240
1008C_02	3,971	2,319	2,510
1008E_01	10,345	6,041	6,538
1011_01	6,397	3,736	4,043

Linkage Analysis

Load duration curve (LDC) analyses (including flow duration curve (FDC) analyses) were used for analyzing indicator bacteria loads and instream water quality for the segments in this project. The Technical Support Document has details about these analyses.

Margin of Safety

The margin of safety (MOS) is designed to account for any uncertainty that may arise in specifying water quality control strategies for the complex environmental processes that affect water quality. Quantification of this uncertainty, to the extent possible, is the basis for assigning an MOS. The TMDLs covered by this addendum incorporate an explicit MOS by setting a target for indicator bacteria loads that is 5 percent lower than the geometric mean criterion. For primary contact recreation, this equates to a geometric mean target for *E. coli* of 120 MPN/100 mL. The net effect of the TMDL with MOS is that the assimilative capacity or allowable pollutant loading of each water body is slightly reduced.

Pollutant Load Allocation

Pollutant load allocations were developed using analysis of the FDC and the LDC method for the 10-year period of January 2001 through December 2010. To establish the subwatershed targets, TMDL calculations and associated allocations are established for the most-downstream sampling location in each subwatershed that is routinely sampled. This establishes a distinct TMDL for the 303(d) listed water bodies.

To calculate the bacteria load at the criterion for the segments, the flow rate at each flow exceedance percentile is multiplied by a unit conversion factor (*24,465,755 deciliters/cubic foot * seconds/day*) and the *E. coli* criterion. This calculation produces the maximum bacteria load in the stream without exceeding the instantaneous standard over the range of flow conditions. *E. coli* loads are plotted versus flow exceedance percentiles as an LDC. The x-axis indicates the flow exceedance percentile, while the y-axis is expressed in terms of a bacteria load.

To estimate existing loading in the addendum subwatersheds, bacteria observations from 2001 to 2010 are paired with the flows measured or estimated in that segment on the same date. Pollutant loads are then calculated by multiplying the measured bacteria concentration by the flow rate and a unit conversion factor of *24,465,755 dL/ft^3 * seconds/day*. The associated flow exceedance percentile is then matched with the measured flow. The observed bacteria loads are added to the LDC plot as points. These points represent individual ambient water quality samples of bacteria. Points above the LDC indicate the bacteria instantaneous standard was exceeded at the time of sampling. Conversely, points under the LDC indicate the sample met the criterion.

The LDC approach recognizes that the assimilative capacity of a water body depends on the flow, and that maximum allowable loading varies with flow condition. Existing loading and loads that meet the TMDL water quality target can also be calculated under different flow conditions.

The load allocation goal for these AUs is based on data analysis using the geometric mean criterion (126 MPN/100mL) since it is anticipated that achieving the geometric mean over an extended period of time will likely ensure that the single sample criterion (399 MPN/100 mL) will also be achieved.

Figure 7 represents the LDC for Upper Panther Branch AU 1008B_01 and is based on *E. coli* bacteria measurements at sampling location 16629 (Upper Panther Branch approximately 80 m upstream of Permit WQ0012597-001). The LDC indicates that *E. coli* levels often exceed the instantaneous and geometric mean water quality criteria under the Wet Conditions flow regime, often exceed only the geometric mean criterion under the Moderate Conditions, and are generally less than both criteria under the Dry Conditions. On Figure 7 the geometric means of the measured data for each flow regime generally support these observations. Wet weather influenced *E. coli* observations are found under all flow conditions. The allocation goal for the AU used in the final TMDL equation was based on the flow regime with the highest bacteria load (0–30th percentile).

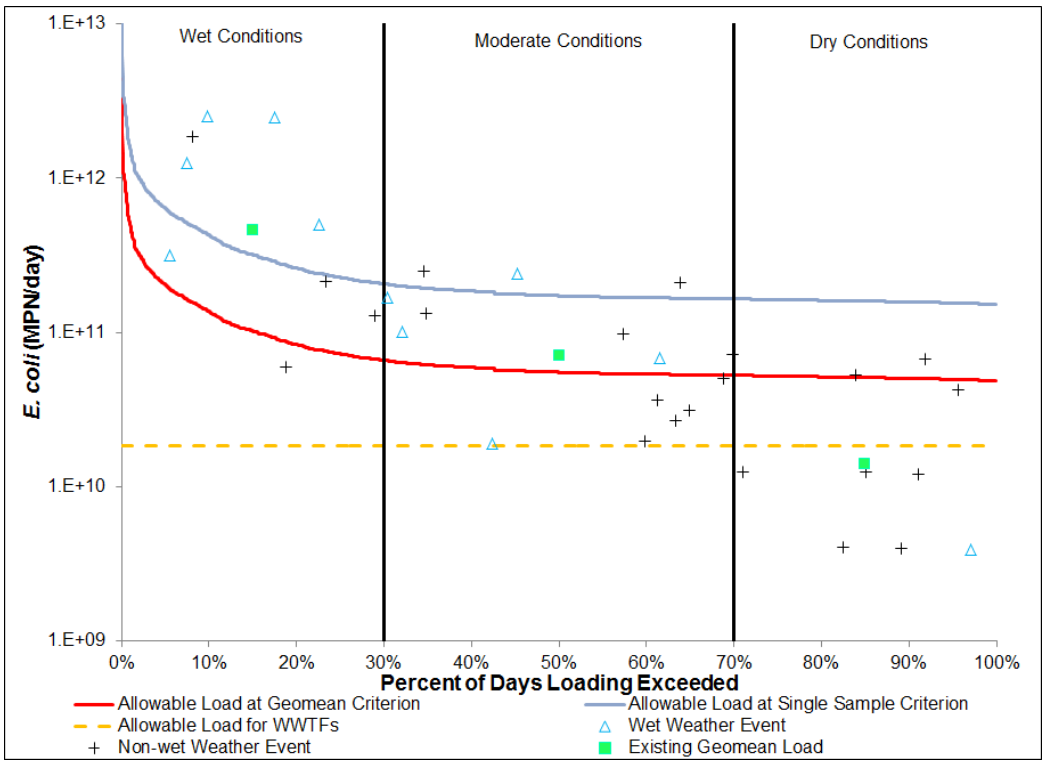

Figure 7. Load Duration Curve for Upper Panther Branch (1008B_01)

Figure 8 represents the LDC for Upper Panther Branch AU 1008B_02 and is based on *E. coli* bacteria measurements at sampling location 16630 (Upper Panther Branch approximately 170 m downstream of Permit WQ0012597-001). The LDC indicates that *E. coli* levels often exceed the instantaneous and geometric mean water quality criteria under the Wet Conditions flow regime and often exceed the geometric mean criterion under the Moderate and Dry Conditions. On Figure 8 the geometric means of the measured data for each flow regime generally support these observations. Wet weather influenced *E. coli* observations are found under all flow conditions. The allocation goal for the AU used in the final TMDL equation was based on the flow regime with the highest bacteria load (0–30th percentile).

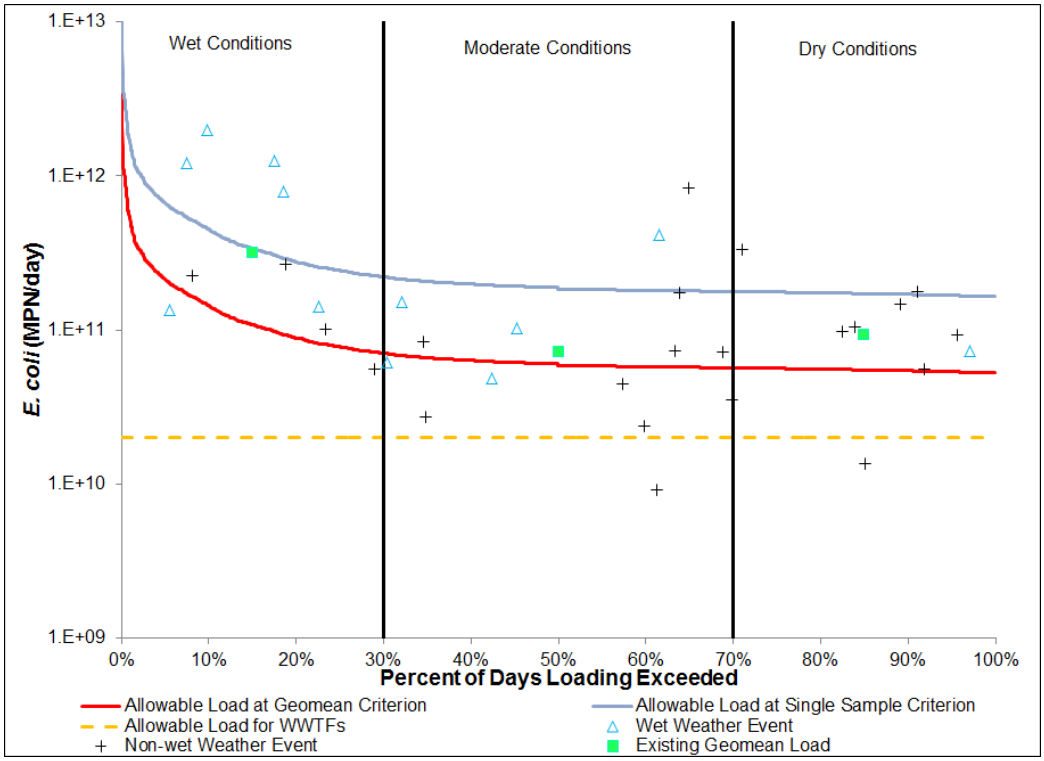

Figure 8. Load Duration Curve for Upper Panther Branch (1008B_02)

Figure 9 represents the LDC for Lower Panther Branch AU 1008C_01 and is based on *E. coli* bacteria measurements at sampling location 16628 (Lower Panther Branch 91 m downstream of Sawdust Rd.). The LDC indicates that *E. coli* levels often exceed the instantaneous and geometric mean water quality criteria under the Wet Conditions flow regime and often exceed the geometric mean criterion under the Moderate and Dry Conditions. On Figure 9 the geometric means of the measured data for each flow regime generally support these observations. Wet weather influenced *E. coli* observations are found under high and mid-range flow conditions. The allocation goal for the AU used in the final TMDL equation was based on the flow regime with the highest bacteria load (0–30th percentile).

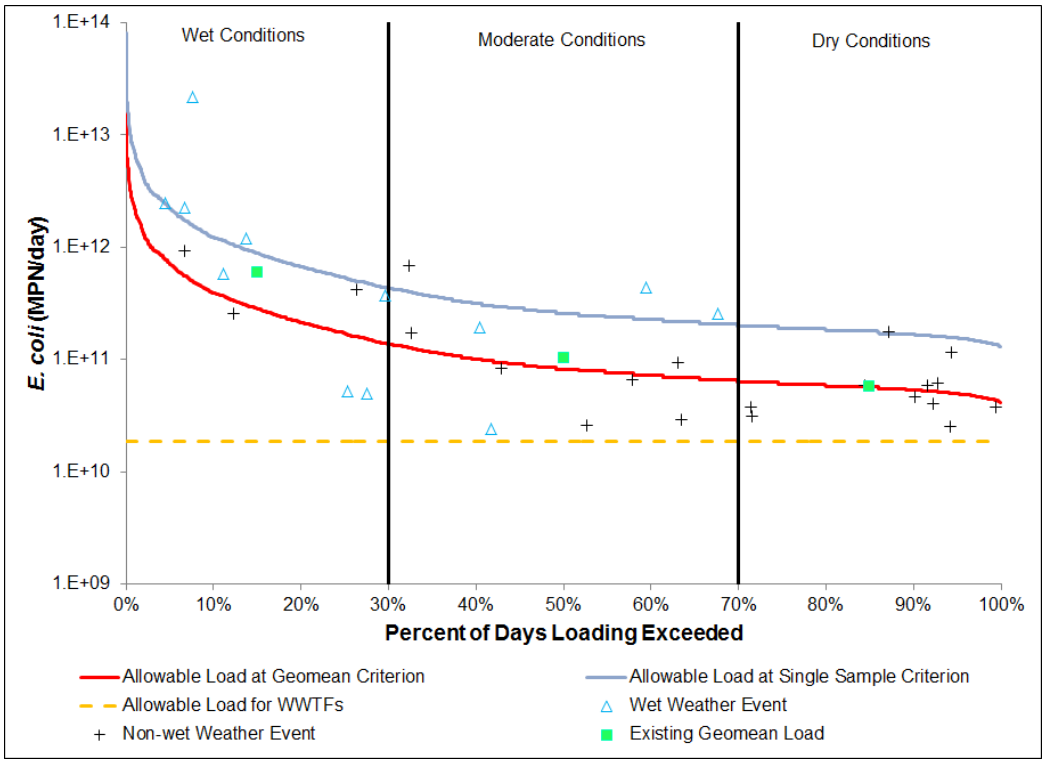

Figure 9. Load Duration Curve for Lower Panther Branch (1008C_01)

Figure 10 represents the LDC for Lower Panther Branch AU 1008C_02 and is based on *E. coli* bacteria measurements at sampling location 16627 (Lower Panther Branch 180 m upstream of Sawdust Rd.). The LDC indicates that *E. coli* levels do not often exceed the instantaneous water quality criterion. The LDC also indicates that the *E. coli* levels often exceed the geometric mean criterion under the Wet Conditions flow regime, but do not as often exceed the geometric mean criterion under the Moderate and Dry Conditions. On Figure 10 the geometric means of the measured data for each flow regime generally support these observations. Wet weather influenced E. coli observations are found under high and mid-range flow conditions. The allocation goal for the AU used in the final TMDL equation was based on the flow regime with the highest bacteria load (0–30th percentile).

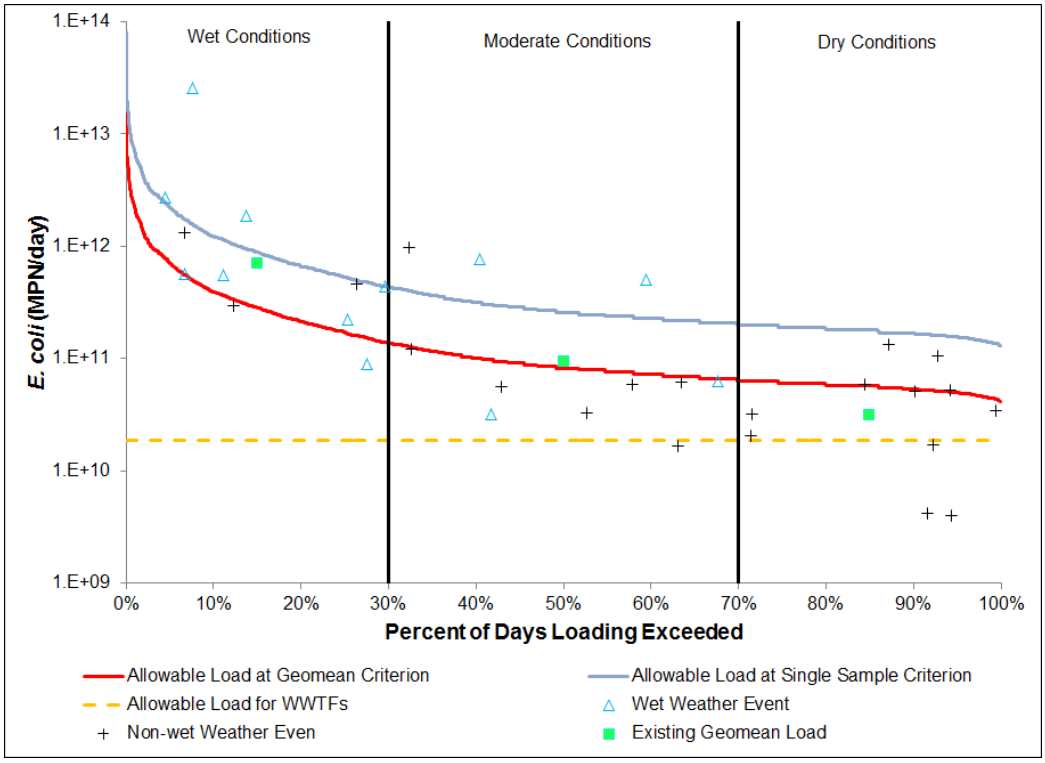

Figure 10. Load Duration Curve for Lower Panther Branch (1008C_02)

Figure 11 represents the LDC for Bear Branch AU 1008E_01 and is based on E. coli bacteria measurements at sampling location 16631 (Bear Branch at Research Forest Dr.). The LDC indicates that E. coli levels often exceed the instantaneous and geometric mean water quality criteria under the Wet Conditions flow regime and often exceed the geometric mean criterion under the Moderate and Dry Conditions. On Figure 11 the geometric means of the measured data for each flow regime generally support these observations. Wet weather influenced E. coli observations are found under all flow conditions. The allocation goal for the AU used in the final TMDL equation was based on the flow regime with the highest bacteria load (0–30th percentile).

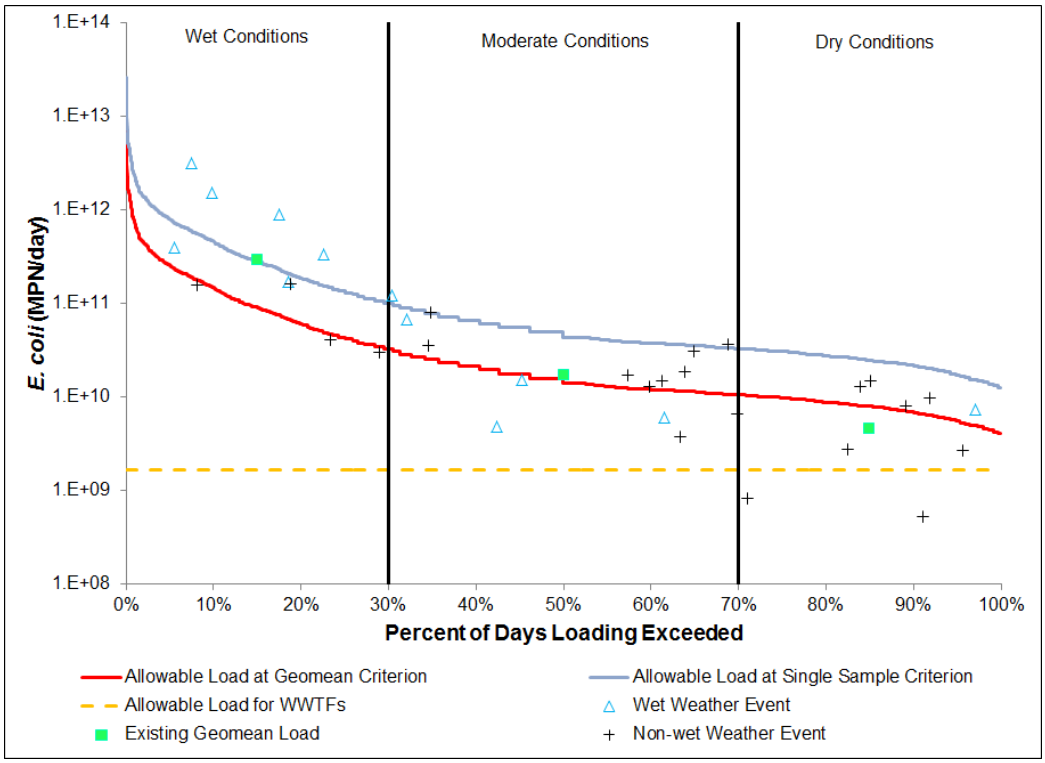

Figure 11. Load Duration Curve for Bear Branch (1008E_01)

Figure 12 represents the LDC for Peach Creek AU 1011_01 and is based on *E. coli* bacteria measurements at sampling location 16625 (Peach Creek at Old Highway 105). The LDC indicates that *E. coli* levels often exceed the instantaneous and geometric mean water quality criteria under the Wet Conditions flow regime and are often below both criteria under the Moderate and the Dry Conditions. On Figure 12 the geometric means of the measured data for each flow regime generally support these observations. Wet weather influenced *E. coli* observations are found under all flow conditions. The allocation goal for the AU used in the final TMDL equation was based on the flow regime with the highest bacteria load (0–30th percentile).

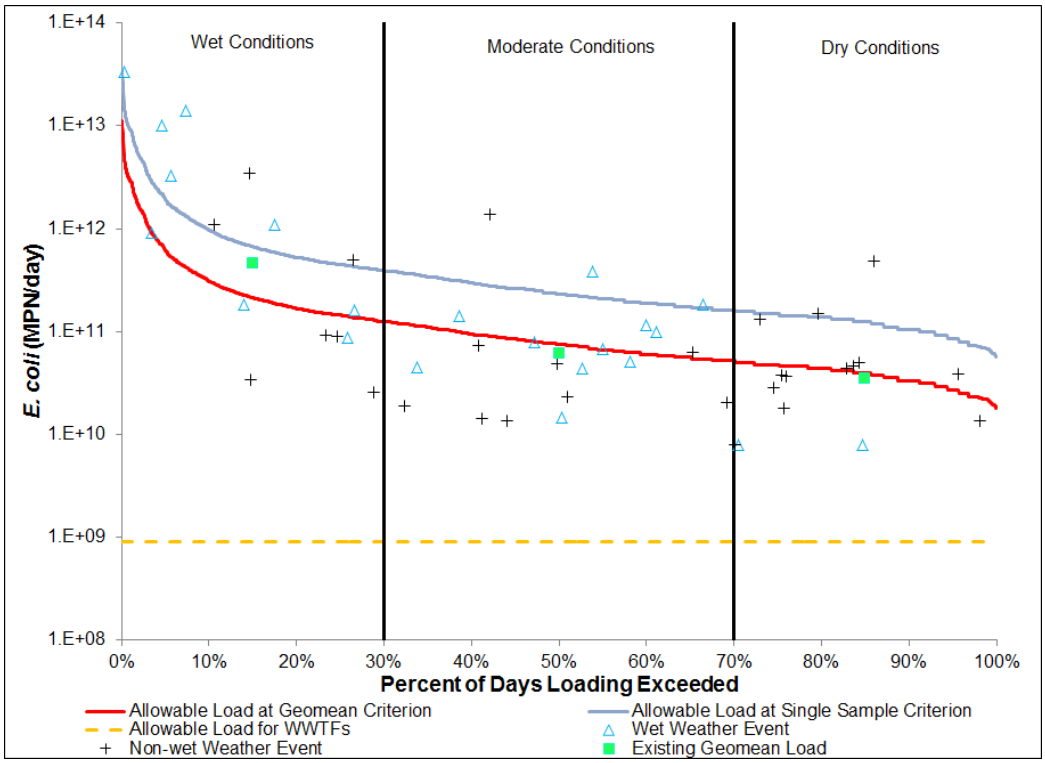

Figure 12. Load Duration Curve for Peach Creek (1011_01)

Wasteload Allocation

The wasteload allocation (WLA) is the sum of loads from regulated sources.

WWTFs

TPDES-permitted wastewater treatment facilities (WWTFs) are allocated a daily wasteload (WLA_{WWTF}) calculated as their permitted discharge flow rate multiplied by one-half the instream geometric mean water quality criterion. One-half of the water quality criterion is used as the target to provide instream and downstream load capacity, and to provide consistency with other TMDLs developed in the Houston area.

Table 11 summarizes the WLA for the TPDES-permitted facilities within the Study Area. WLAs were established for the facilities within the watersheds included in the original TMDL document and its subsequent Water Quality Man-

agement Plan (WQMP) updates. These facilities are being assigned to specific subwatersheds in this addendum.

Table 11. Waste Load Allocations for NPDES and TPDES-Permitted Facilities

AU	TPDES Number	NPDES Number	Facility Name	Final Permitted Flow (MGD)	*E. coli* WLA_{WWTF} (billion MPN/day)
1008B_01	WQ0012597-001	TX0091715	The Woodlands WWTP 2	7.800	18.60
1008C_02	WQ0011401-001	TX0054186	Woodlands	7.800 [a]	18.60
1008C_01	WQ0013697-001	TX0090000	Cedarstone WWTP	0.003	0.007154
1008E_01	WQ0014141-001	TX0120073	Old Egypt Regional Business Center	0.450	1.073
1008E_01	WQ0014918-001	TX0131725	Eaglestar WWTP	0.100	0.2385
1008E_01	WQ0014909-001	TX0131652	Lincoln Manufacturing	0.050	0.1192
1008E_01	WQ0014013-001	TX0118028	Greenfield Forest WWTP	0.050	0.1192
1008E_01	WQ0012703-001	TX0092843	Bear Branch Plant	0.048	0.1145
1011_01	WQ0013389-001	TX0102512	City of Splendora WWTP	0.300	0.7154
1011_01	WQ0011143-001	TX0082511	Splendora Elementary School	0.040	0.09539
1011_01	WQ0011143-002	TX0117463	Splendora ISD WWTF	0.040	0.09539

[a] *San Jacinto River Authority WQ0011401-001 has two permitted outfalls and their combined full permitted flow is 7.8 MGD.*

Stormwater

Stormwater discharges from MS4, industrial, and construction areas are considered permitted or regulated point sources. Therefore, the WLA calculations must also include an allocation for regulated stormwater discharges (WLA_{SW}). A simplified approach for estimating the WLA for these areas was used in the development of these TMDLs due to the limited amount of data available, the complexities associated with simulating rainfall runoff, and the variability of stormwater loading.

The percentage of the subwatersheds that are under the jurisdiction of stormwater permits (i.e., defined as the area designated as urbanized area in the 2010 US Census) is used to estimate the amount of the overall runoff load to be allocated as the regulated stormwater contribution in the WLA_{SW} component of the TMDL. The load allocation component of the TMDL corresponds to direct nonpoint source (unregulated) runoff and is the difference between the total load from stormwater runoff and the portion allocated to WLA_{SW}. For the AUs addressed in this TMDL, the urbanized area and percent of each subwatershed within the urbanized area was previously provided in Table 7.

Load Allocation

The load allocation is the sum of loads from unregulated sources. A complexity of the load allocation term occurs as a result of reservoirs because they 1) modify downstream hydrology by attenuating peak flows and reducing overall flow and 2) reduce bacteria concentrations by providing favorable conditions for settling and die-off. If a reservoir is of sufficient size, it represents a disruption of the downstream accumulation of bacteria loadings. For the pollutant load allocation computation, reservoirs that are designated by TCEQ as either a classified segment or an unclassified segment are considered significant enough in size to require being considered separately in the load allocation term. For water bodies associated with the Lake Houston watershed and associated with the AU subwatersheds, the only reservoir meeting this definition is Lake Woodlands (Segment 1008F). To accommodate the disruption in downstream bacteria loadings from a significant reservoir, the bacteria loadings associated with its releases are considered separately. The total load allocation (LA_{TOTAL}), therefore, becomes defined as the sum of the upstream loadings arising from a significant upstream reservoir that enters into an AU (LA_{RES}) and the remaining bacteria load that arises from unregulated sources within the AU and upstream AUs not associated with a significant reservoir (LA_{AU}).

Allowance for Future Growth

As described in the original TMDL document, future growth of existing or new point sources is not limited by these TMDLs as long as the sources do not cause indicator bacteria to exceed the limits. The assimilative capacity of streams increases as the amount of flow increases. Consequently, increases in flow allow for additional indicator bacteria loads if the concentrations are at or below the contact recreation standard. New or amended permits for wastewater discharge facilities will be evaluated case by case.

To account for the probability that increased or additional flows from WWTFs may occur in Upper Panther Brach (AU 1008B_01 and 1008B_02), Lower Panther Branch (1008C_01 and 1008C_02), Bear Branch (1008E_01) and Peach Creek (1011_01), a provision for future growth was included in the TMDL calculations by estimating permitted flows to year 2035 using population projections completed by H-GAC.

The three-tiered antidegradation policy in the SWQS prohibits an increase in loading that would cause or contribute to degradation of an existing use. The antidegradation policy applies to both point and nonpoint source pollutant discharges. In general, antidegradation procedures establish a process for reviewing individual proposed actions to determine if the activity will degrade water quality. The TMDLs in this document will result in protection of existing beneficial uses and conform to Texas's antidegradation policy.

TMDL Calculations

Table 12 summarizes the estimated maximum allowable load of *E. coli* for the AUs included in this project.

The final TMDL allocations required to comply with the requirements of 40 Code of Federal Regulations (CFR) 130.7 are summarized in Table 13. In this table, the future capacity for WWTF has been added to the WLA_{WWTF}.

TMDL values and allocations in Table 13 are derived from calculations using the existing water quality criteria for *E. coli*. However, designated uses and water quality criteria for these water bodies are subject to change through the TCEQ SWQS revision process. Figures 13 through 18 were developed to demonstrate how assimilative capacity, TMDL calculations, and pollutant load allocations change in relation to a number of hypothetical water quality criteria. The equations provided along with Figures 13 through 18 allow the calculation of new TMDLs and pollutant load allocations based on any potential new water quality criteria for *E. coli*.

Seasonal Variation

Federal regulations (40 CFR §130.7(c)(1)) require that TMDLs account for seasonal variation in watershed conditions and pollutant loading. Seasonal variation was accounted for in these TMDLs by using more than five years of water quality data and by using the longest period of USGS flow records when estimating flows to develop flow exceedance percentiles.

Analysis of the seasonal differences in indicator bacteria concentrations were assessed by comparing historical bacteria concentrations collected in the warmer months against those collected during the cooler months. This analysis of *E. coli* data indicated that there was a significant difference (α=0.05) in indicator bacteria for Upper Panther Branch (1008B_01) and Peach Creek (1011_01) with the cool season having the higher concentrations. Seasonality was not detected in the remaining four impaired AUs.

Public Participation

A presentation on this addendum was given at the annual meeting of the Bacteria Implementation Group (BIG) in Houston on May 14, 2013. The public will have an opportunity to comment on this document during a 30-day WQMP comment period. Notice of the public comment period will be sent to the BIG and posted at <www.tceq.texas.gov/permitting/wqmp/WQmanagement _comment.html>. The document will be posted at <www.tceq.texas.gov/permitting/wqmp/WQmanagement_updates.html>. The technical support document for this project is posted on the TMDL project page at <www.tceq.texas.gov/waterquality/tmdl/nav/42-houstonbacteria/42-houstonareabacteria-library/#lakehouston>.

Implementation and Reasonable Assurance

The four segments and six AUs covered by this addendum are within the existing bacteria TMDL watersheds upstream of Lake Houston. These subwatersheds are within the area covered by the I-Plan developed by the BIG for bacteria TMDLs throughout the greater Houston area. Please refer to the original TMDL document for additional information regarding implementation and reasonable assurance.

Table 12. *E. coli* TMDL Summary for Impaired AUs of this Addendum

All loads expressed as Billion MPN/day

AU	Stream Name	TMDL[a]	MOS[b]	WLA_{WWTF}[c]	WLA_{SW}[d]	LA_{AU}[e]	LA_{RES}	LA_{TOTAL}[f]	Future Growth[g]
1008B_01	Upper Panther Branch	102.7	5.14	18.60	39.64	27.84	0	27.84	11.50
1008B_02	Upper Panther Branch	109.0	5.45	20.27	56.29	14.78	0	14.78	12.17
1008C_01	Lower Panther Branch	282.5	2.91	18.61	30.62	2.10	224.2	226.3	4.06
1008C_02	Lower Panther Branch	282.0	2.89	18.60	31.90	0.32	224.2	224.5	4.06
1008E_01	Bear Branch	91.10	4.56	1.66	75.22	8.98	0	8.98	0.67
1011_01	Peach Creek	214.1	10.70	0.91	3.05	198.1	0	198.1	1.33

[a] *Maximum allowable load for the highest flow range (0 to 30th percentile flows)*

[b] *$MOS = 0.05 * (TMDL – LA_{RES})$*

[c] *Sum of loads from the WWTF discharging upstream of the TMDL station. Individual loads are calculated as permitted flow * 126/2 (E. coli) MPN/100mL*conversion factor*

[d] *$WLA_{SW} = (TMDL – MOS – WLA_{WWTF} – LA_{RES} – Future\ Growth)*(percent\ of\ drainage\ area\ covered\ by\ stormwater\ permits)$*

[e] *$LA_{AU} = TMDL – MOS – WLA_{WWTF} – WLA_{SW} – LA_{RES} – Future\ Growth$*

[f] *$LA_{TOTAL} = LA_{AU} + LA_{RES}$*

[g] *Projected increase in WWTF permitted flows*126/2*conversion factor*

Table 13. Final TMDL Allocations for Impaired AUs of this Addendum

All loads expressed as Billion MPN/day

AU	TMDL[a]	WLA_{WWTF}[b]	WLA_{SW}	LA_{TOTAL}[c]	MOS
1008B_01	102.7	30.10	39.64	27.84	5.14
1008B_02	109.0	32.44	56.29	14.78	5.45
1008C_01	282.5	22.66	30.62	226.3	2.91
1008C_02	282.0	22.66	31.90	224.5	2.89
1008E_01	91.10	2.33	75.22	8.98	4.56
1011_01	214.1	2.24	3.05	198.1	10.70

[a] $TMDL = WLA_{WWTF} + WLA_{STORMWATER} + LA + MOS$

[b] $WLA_{WWTF} = WLA_{WWTF} + Future\ Growth$

[c] $LA_{TOTAL} = LA_{AU} + LA_{R}$

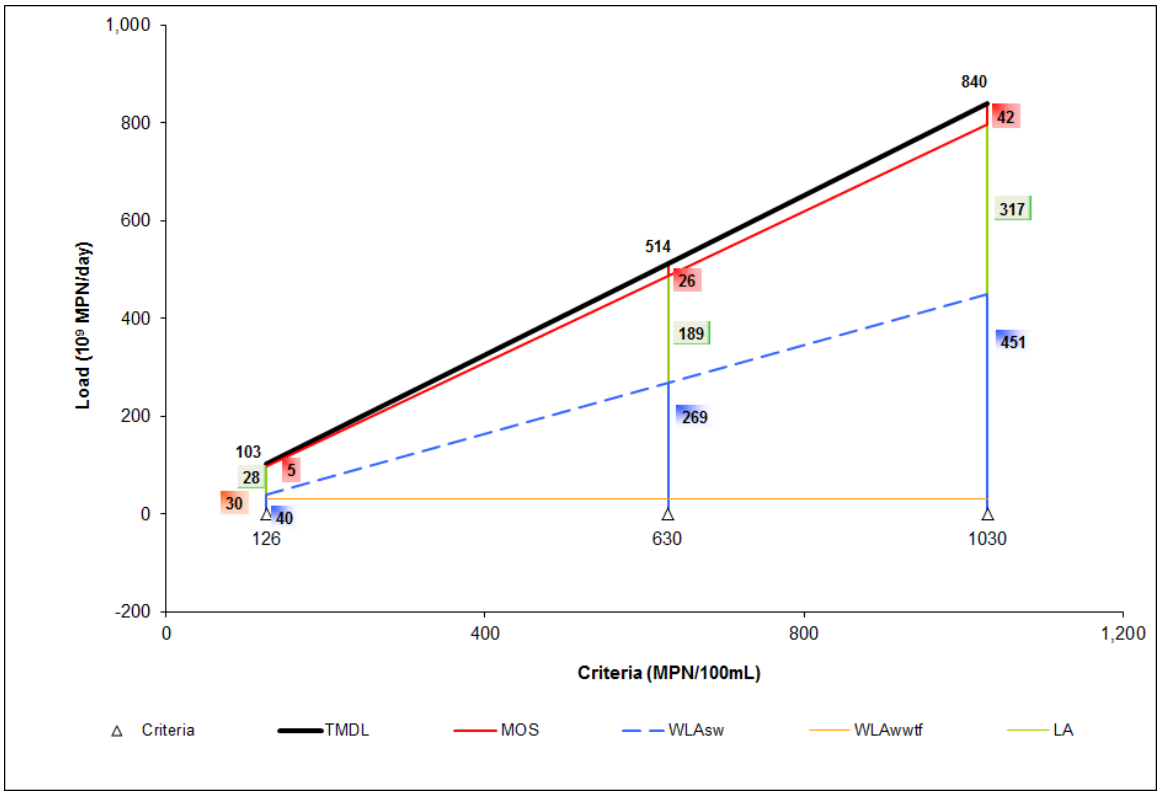

Figure 13. Allocation Loads for Upper Panther Branch (1008B_01) as a Function of Water Quality Criteria

Equations for calculating new TMDL and Allocations (in billion MPN/day)

$$TMDL = 0.81519 * Std$$

$$WLA_{WWTF} = 30.10$$

$$WLA_{sw} = 0.45494 * Std - 17.68$$

$$LA_{TOTAL} = 0.31949 * Std - 12.42$$

$$MOS = 0.04076 * Std$$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA_{TOTAL} = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

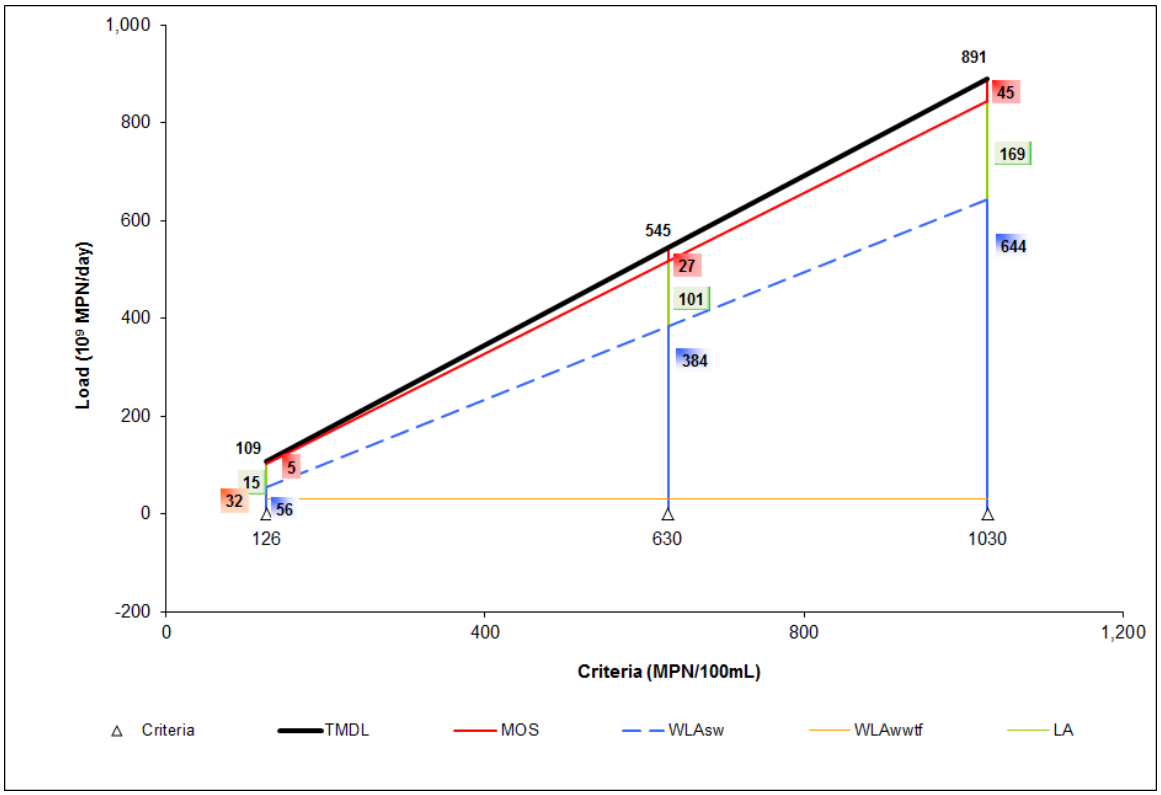

Figure 14. Allocation Loads for Upper Panther Branch (1008B_02) as a Function of Water Quality Criteria

Equations for Calculating New TMDL and Allocations (in billion MPN/day)

$$TMDL = 0.86469 * Std$$

$$WLA_{WWTF} = 32.44$$

$$WLA_{sw} = 0.65059 * Std - 25.69$$

$$LA_{TOTAL} = 0.17086 * Std - 6.75$$

$$MOS = 0.04323 * Std$$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA_{TOTAL} = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

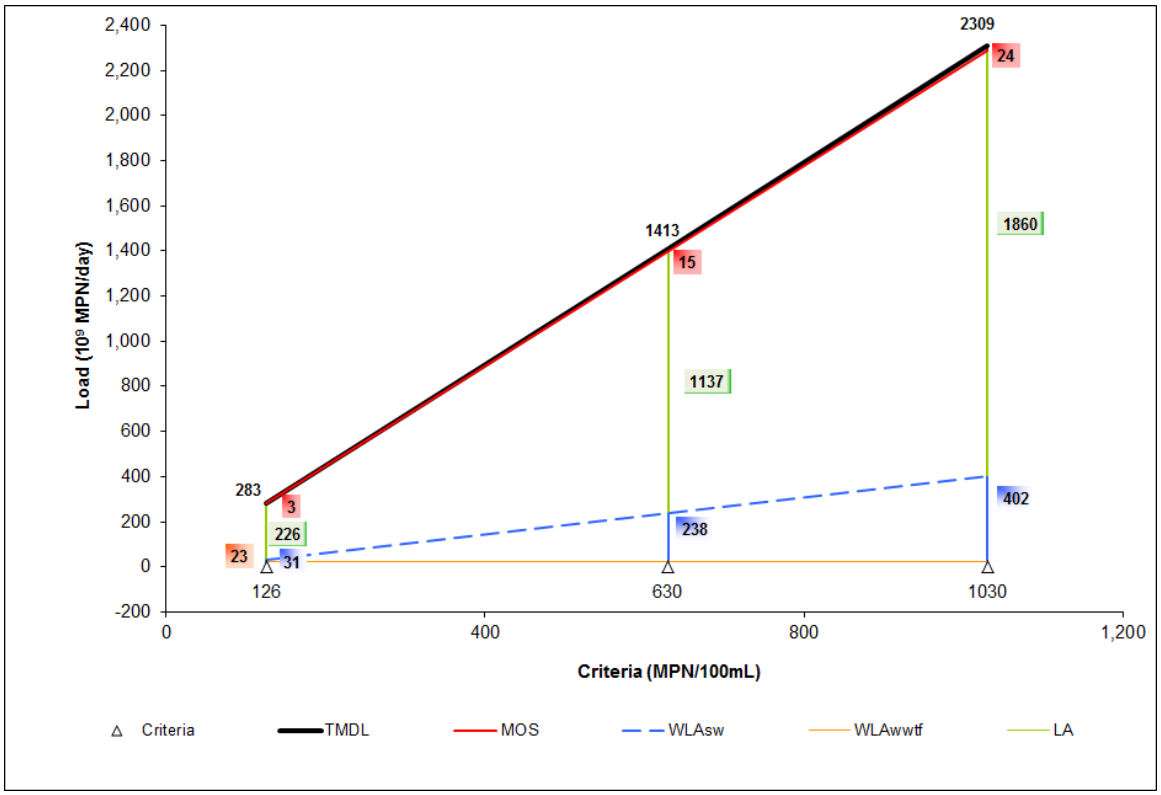

Figure 15. Allocation Loads for Lower Panther Branch (1008C_01) as a Function of Water Quality Criteria

Equations for Calculating New TMDL and Allocations (in billion MPN/day)

$$TMDL = 2.24211 * Std$$

$$WLA_{WWTF} = 22.66$$

$$WLA_{sw} = 0.41136 * Std - 21.21$$

$$LA_{TOTAL} = 1.80761 * Std - 1.45$$

$$MOS = 0.02313 * Std$$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA_{TOTAL} = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

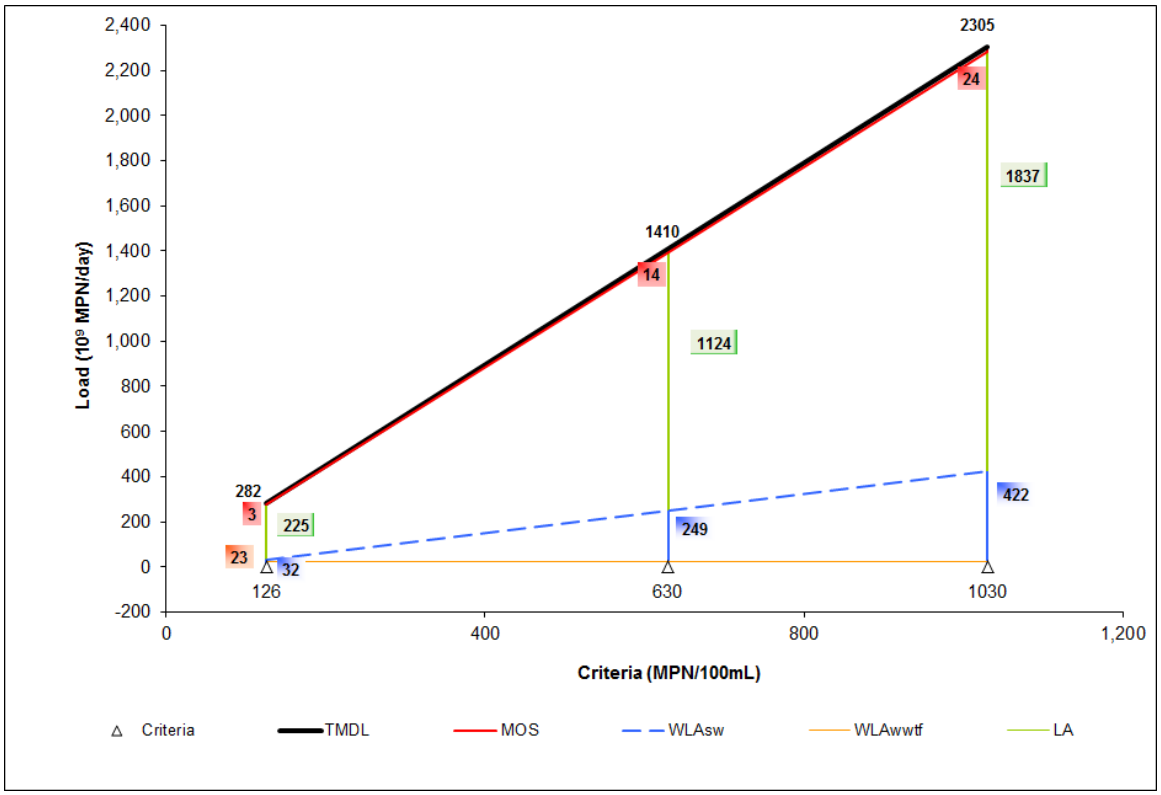

Figure 16. Allocation Loads for Lower Panther Branch (1008C_02) as a Function of Water Quality Criteria

Equations for Calculating New TMDL and Allocations (in billion MPN/day)

$$TMDL = 2.23777 * Std$$

$$WLA_{WWTF} = 22.66$$

$$WLA_{sw} = 0.43113 * Std - 22.43$$

$$LA = 1.78372 * Std - 0.22$$

$$MOS = 0.02292 * Std$$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA_{TOTAL} = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

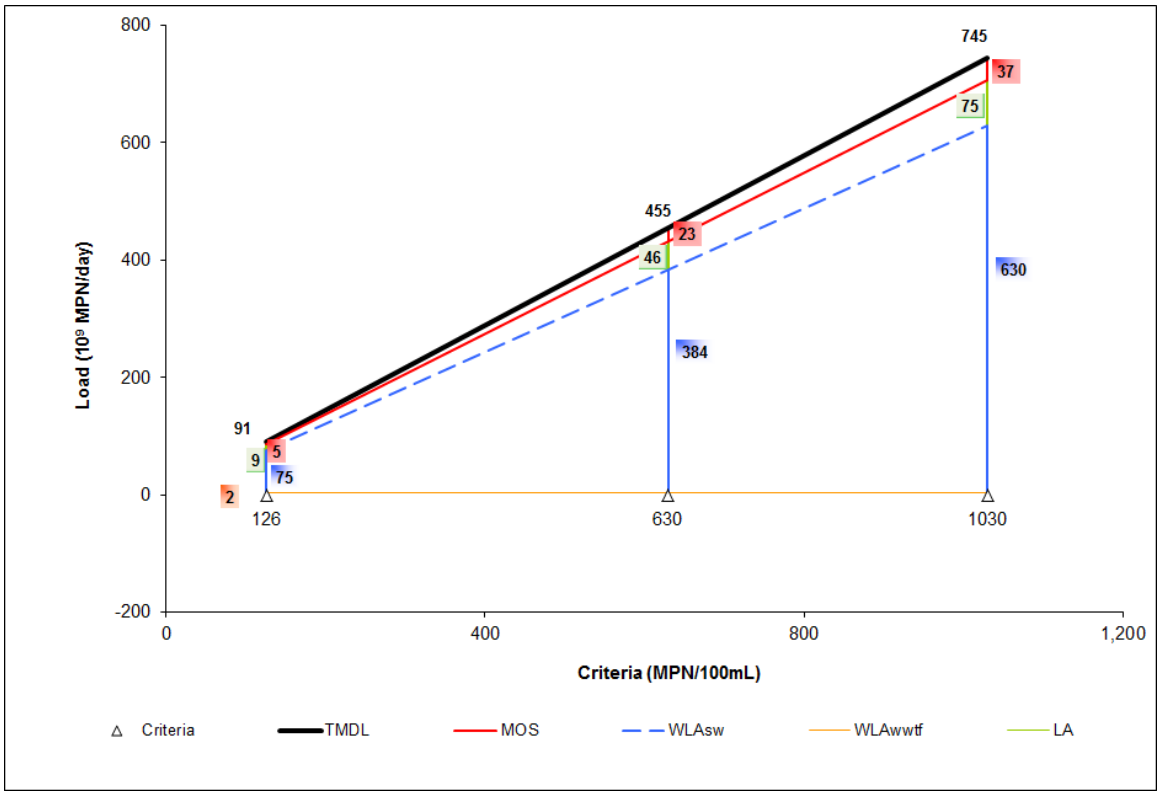

Figure 17. Allocation Loads for Bear Branch (1008E_01) as a Function of Water Quality Criteria

Equations for Calculating New TMDL and Allocations (in billion MPN/day)

$$TMDL = 0.72298 * Std$$

$$WLA_{WWTF} = 2.33$$

$$WLA_{sw} = 0.61356 * Std - 2.09$$

$$LA = 0.07327 * Std - 0.25$$

$$MOS = 0.03615 * Std$$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

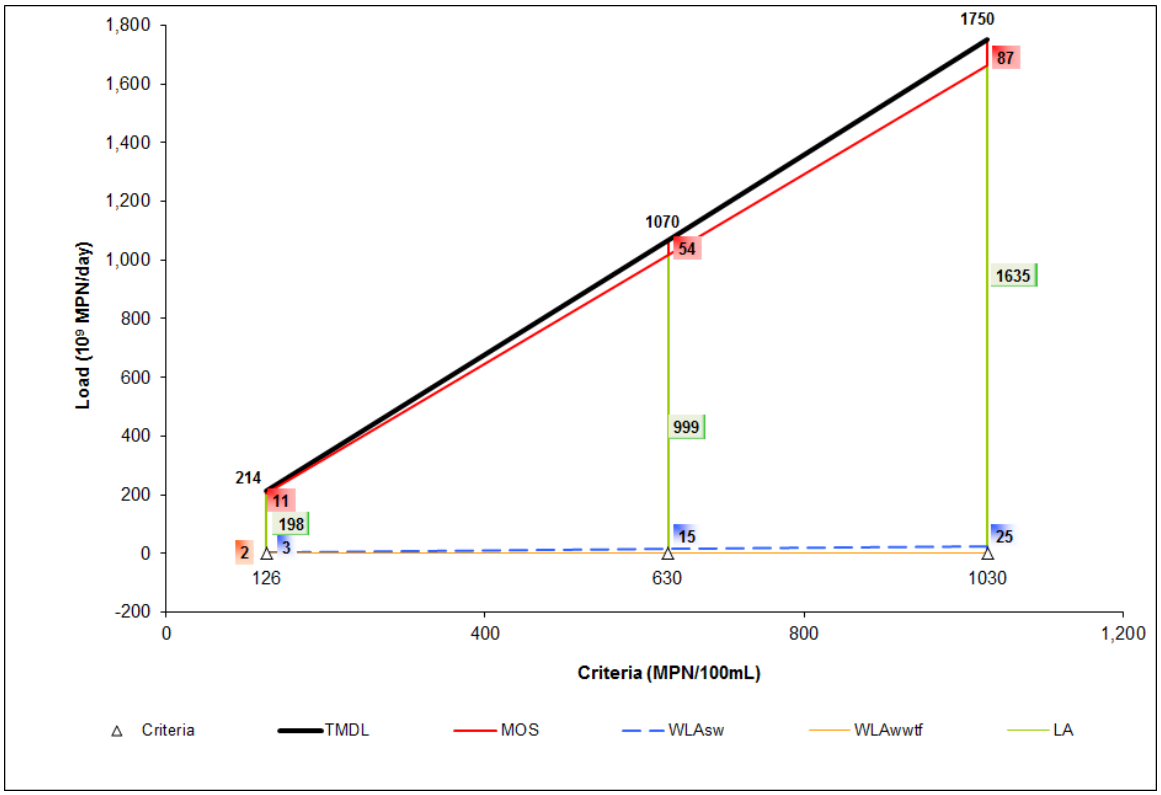

Figure 18. Allocation Loads for Peach Creek (1011_01) as a Function of Water Quality Criteria

Equations for Calculating New TMDL and Allocations (in billion MPN/day)

$$TMDL = 1.69886 * Std$$

$$WLA_{WWTF} = 2.24$$

$$WLA_{sw} = 0.02445 * Std - 0.03$$

$$LA_{TOTAL} = 1.58947 * Std - 2.20$$

$$MOS = 0.08494 * Std$$

Where:

Std = Revised Contact Recreation Standard

WLA_{WWTF} = Waste load allocation (permitted WWTF load + future growth)

WLA_{SW} = Waste load allocation (permitted stormwater)

LA_{TOTAL} = Total load allocation (non-permitted source contributions)

MOS = Margin of Safety

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