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Fecal Coliform Bacteria Total Maximum Daily Loads for Assessment Units in the Commonwealth of Puerto Rico

Plans and Special Projects Division

Evaluation and Strategic Planning Area

ENVIRONMENTAL QUALITY BOARD

PO BOX 11488

SAN JUAN, PUERTO RICO 00910

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1 INTRODUCTION

Section 303(d) of the Clean Water Act and the U.S. Environmental Protection Agency's (EPA's) Water Quality Planning and Management Regulations (Title 40 of the *Code of Federal Regulations* [CFR] Part 130) require states to develop total maximum daily loads (TMDLs) for waterbodies that are not meeting their designated uses even though pollutant sources have implemented technology-based controls. A TMDL establishes the allowable load of a pollutant or other quantifiable parameters on the basis of the relationship between pollutant sources and in-stream water quality. A TMDL provides the scientific basis for a state to establish water quality-based controls to reduce pollution from both point and nonpoint sources and restore and maintain the quality of the state's water resources (USEPA 1991).

EPA Region 2 and the Puerto Rico Environmental Quality Board (PREQB) have coordinated a watershed assessment and an analysis of ambient water quality monitoring data to support the calculation of fecal coliform bacteria TMDLs for assessment units in Puerto Rico where TMDLs have not been previously developed. This document presents the results of the TMDL study and provides the technical basis for calculating the TMDLs.

2 PROBLEM IDENTIFICATION

2.1 Background

Puerto Rico consists of the main island of Puerto Rico and various smaller islands, including Culebra, Mona, Vieques, Desecheo, and Caja de Muertos. There are also many smaller islands including Monito and "La Isleta de San Juan" which includes Old San Juan and Puerta de Tierra and is connected to the main island by bridges. The commonwealth is composed of 78 municipalities, where all, except two (Vieques and Culebra) are located on the main island.

The Commonwealth of Puerto Rico has an area of 8,870 km^2 (3,420 sq mi). The maximum length of the main island from east to west is approximately 180 km (110 mi), and the maximum width from north to south is approximately 65 km (40 mi). Puerto Rico is the smallest of the Greater Antilles, and is mostly mountainous with large coastal areas in the north and south. The dominant mountain range is called "La Cordillera Central" (The Central Range), and the highest elevation in Puerto Rico is Cerro Punta at 1,339 meters (4,393 ft). Another significant peak is El Yunque, one of the highest in the Sierra de Luquillo at the El Yunque National Forest, with an elevation of 1,065 m (3,494 ft).

Puerto Rico is composed primarily of volcanic and plutonic rocks, overlain by younger carbonates and other sedimentary rocks. Most of the caverns and karst topography on the island occurs in the northern region in the carbonates. Puerto Rico lies at the boundary between the Caribbean and North American plates and is being deformed by the tectonic stresses caused by their interaction, which may cause earthquakes and tsunamis.

Puerto Rico has 19 lakes, all man-made, and more than 50 rivers, most originating in the Cordillera Central. Rivers in the northern region of the island are typically longer and of higher water flow rates than those of the south, since the south receives less rain than the central and northern regions.

Located in the tropics, Puerto Rico has an average temperature of 82.4 °F (28 °C) throughout the year. Temperatures do not change drastically throughout the seasons. The temperature in the south is usually a few degrees higher than the north and temperatures in the central interior mountains are always cooler than the rest of the island. The Hurricane season spans from June to November. The all-time low in Puerto Rico has been 39 °F (4 °C), registered in Aibonito.

Because of municipal point sources, collection system failure, urban runoff/storm sewers, confined animal feeding operations, agricultural practices, and onsite wastewater systems, many waterbodies no longer meet the applicable water quality standards for Puerto Rico (PRWQSR Section 3.2.4[B][2]). As a result, 66 assessment units are included on Puerto Rico's 2010 Clean Water Act section 303(d) list of impaired waterbodies for fecal coliform. Through this TMDL effort, the remaining 138 assessment units in this watershed were determined to be impaired for fecal coliform. For purposes of developing the loading capacity, the watersheds were divided into 143 subwatersheds. The analysis by region is described as:

a) North: 11 subwatersheds to describe 16 assessment units (*3 assessment units on the 303(d) list and 13 assessment units determined to be impaired for fecal coliform*)
b) East: 40 subwatersheds to describe 66 assessment units (*41 assessment units on the 303(d) list and 25 assessment units determined to be impaired for fecal coliform*)
c) South: 73 subwatersheds to describe 88 assessment units (*15 assessment units on the 303(d) list and 73 assessment units determined to be impaired for fecal coliform*)
d) West: 19 subwatersheds to describe 34 assessment units (*7 assessment units on the 303(d) list and 27 assessment units determined to be impaired for fecal coliform*)

Table 2-1 iterates the crosswalk between subwatersheds by TMDL ID and their respective assessment units.

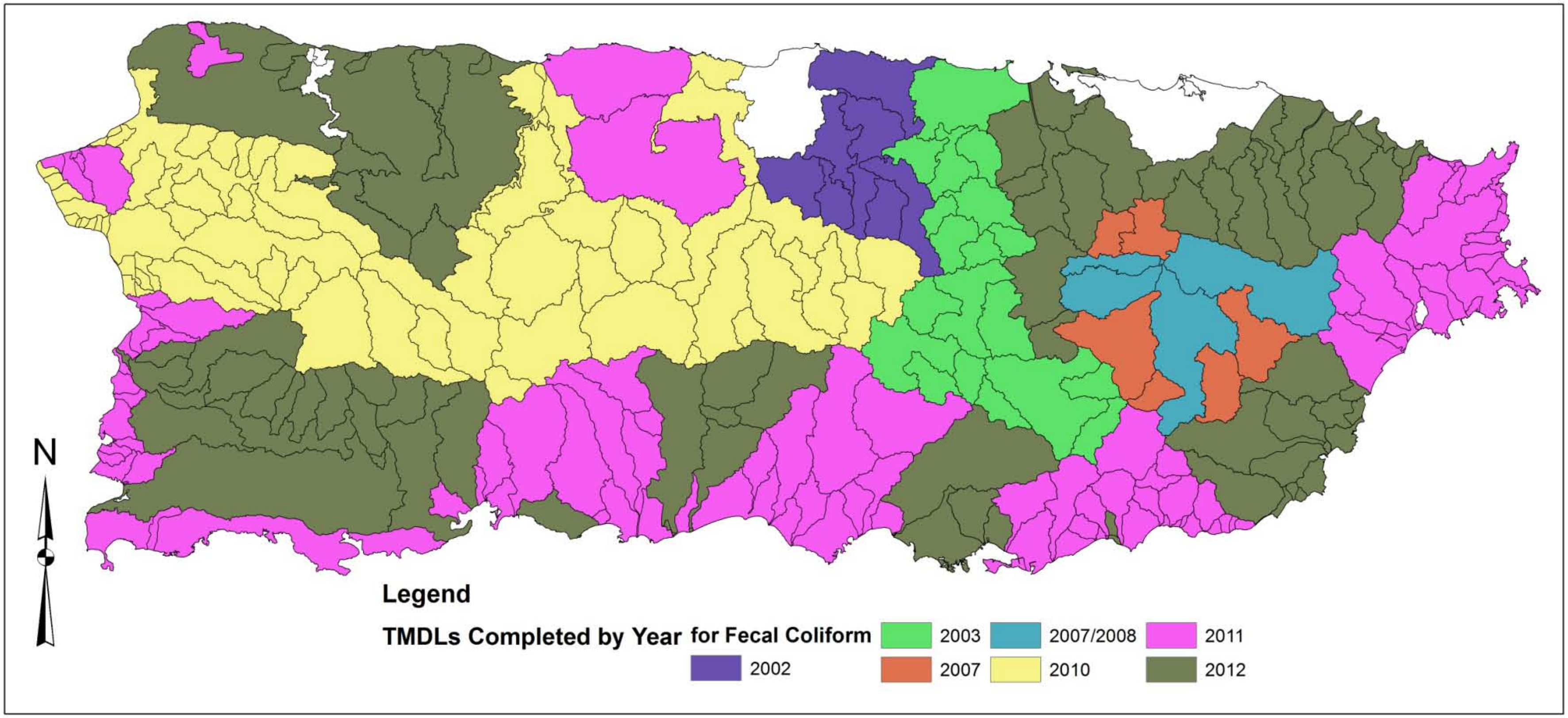

Figure 2-1. The Commonwealth of Puerto Rico and assessment units.

Table 2-1. Assessment units impaired for fecal coliform bacteria (FC) based on Puerto Rico's 2010 section 303(d) list of impairments and/or the TMDL watershed modeling shows impairment.

BASIN ID	BASIN NAME	BASIN SEQUENCE	REGION	TMDL ID	Assessment Unit ID		WATERBODY NAME	PRIORITY	TYPE
					303(d) listed of FC	not listed, impaired for FC			
PRNQ1A	QUEBRADA DE LOS CEDROS	1	N	PRNQ1A		PRNQ1A	QUEBRADA DE LOS CEDROS	Low	Stream
PRNE7.1	CAÑO TIBURONES			PRNE7.1		PRNE7.1	CAÑO TIBURONES	Low	Estuarine
Cano Tiburones Coastal Watershed			N	UNC--1		unnamed	Non-contributing area - Name not assigned		
PRER19A	RIO SABANA	19	E	PREE19A		PREE19A	RIO SABANA	Medium	Estuarine
				PRER19A	PRER19A		RIO SABANA	Medium	Stream
PRER20A	RIO JUAN MARTIN	20	E	PREE20A		PREE20A	RIO JUAN MARTÍN	Medium	Estuarine
					PRER20A		RIO JUAN MARTÍN	Medium	Stream
PREQ21A	QUEBRADA FAJARDO	21	E	PREQ21A	PREQ21A		QUEBRADA FAJARDO	Medium	Stream
						PREN0012	Laguna Grande	Medium	Lake
						PREN0011	Laguna Aguas Prietas	Medium	Lake
PRER22A	RIO FAJARDO	22	E	PREE22A		PREE22A	RIO FAJARDO	Medium	Estuarine
					PRER22A		RIO FAJARDO	Medium	Stream
PRER29A	RIO SANTIAGO	29	E	PREE29A		PREE29A	RIO SANTIAGO	Medium	Estuarine
					PRER29A		RIO SANTIAGO	Medium	Stream
PRER30A	RIO BLANCO	30	E	PREQ30B	PREQ30B		QUEBRADA PEÑA POBRE	High	Stream
				PRER30A		PREE30A	RIO BLANCO	High	Estuarine
					PRER30A		RIO BLANCO	High	Stream
PRER31A	RIO ANTON RUIZ	31	E	PREE31A		PREE31A	RIO ANTON RUIZ	Medium	Estuarine
					PRER31A		RIO ANTON RUIZ	Medium	Stream
PRER23A	RIO DEMAJAGUA	23	E	UCW--5	PRER23A		RIO DEMAJAGUA	Medium	Stream
					PREE23A		RIO DEMAJAGUA	Medium	Estuarine
PREQ24A	QUEBRADA CEIBA	24	E		PREQ24A		QUEBRADA CEIBA	Medium	Stream
PREQ25A	QUEBRADA AGUAS CLARAS	25	E		PREQ25A		QUEBRADA AGUAS CLARAS	Medium	Stream
						PREE25A	QUEBRADA AGUAS CLARAS	Medium	Estuarine
Rio Anton Ruiz to Rio Fajardo Watersheds			E			unnamed	Puerto Medio Mundo to Playa Sardinera Coastal Watersheds		
PRER26A	RIO DAGUAO	26	E	UCW--4	PRER26A		RIO DAGUAO	Medium	Stream
						PREE26A	RIO DAGUAO	Medium	Estuarine
PREQ27A	QUEBRADA PALMA	27	E		PREQ27A		QUEBRADA PALMA	Medium	Stream
						PREE27A	QUEBRADA PALMA	Medium	Estuarine
PREQ28A	QUEBRADA BOTIJAS	28	E		PREQ28A		QUEBRADA BOTIJAS	Medium	Stream
						PREE28A	QUEBRADA BOTIJAS	Medium	Estuarine
PREQ32A	QUEBRADA FRONTERA	32	E	UCW--6	PREQ32A		QUEBRADA FRONTERA	Medium	Stream

BASIN ID	BASIN NAME	BASIN SEQUENCE	REGION	TMDL ID	Assessment Unit ID		WATERBODY NAME	PRIORITY	TYPE
					303(d) listed of FC	not listed, impaired for FC			
Rio Herrera to Las Cabezas de San Juan Coastal Watersheds			E	UCW--26		unnamed	Coastal Watersheds Northeast of Rio Pitahaya mouth		
PRSR40A	RIO JACABOA	40	S	PRSR40A		PRSR40A	RIO JACABOA	Low	Stream
PRSR42A	RIO CHICO	42	S	PRSR42A	PRSR42A		RIO CHICO	Medium	Stream
						PRSE42A	RIO CHICO	Medium	Estuarine
PRSR43A	RIO GRANDE DE PATILLAS	43	S	PRSR43A1	PRSR43A1		RIO GRANDE DE PATILLAS	High	Stream
				UCW--16		PRSE43A	RIO GRANDE DE PATILLAS	High	Estuarine
				PRSR43A2	PRSR43A2		RIO GRANDE DE PATILLAS	High	Stream
				PRSR43B		PRSR43B	RIO MARIN	High	Stream
				PRSL43A1		PRSL43A1	LAGO PATILLAS	High	Lake
PRSR45A	RIO NIGUAS – ARROYO	45	S	PRSR45A		PRSR45A	RIO NIGUAS DE ARROYO	Low	Stream
PRSQ47A	QUEBRADA CORAZON	47	S	PRSR47A		PRSQ47A	QUEBRADA CORAZON	Low	Stream
						PRSE47A	QUEBRADA CORAZON	Low	Estuarine
PRSQ48A	QUEBRADA BRANDERI	48	S	PRSE48A		PRSE48A	QUEBRADA BRANDERI	Low	Estuarine
						PRSQ48A	QUEBRADA BRANDERI	Low	Stream
PRSR49A	RIO GUAMANI	49	S	PRSR49A		PRSR49A	RIO GUAMANI	Low	Stream
PRSR51A	RIO SECO	51	S	PRSE51A		PRSE51A	RIO SECO	Low	Estuarine
						PRSR51A	RIO SECO	Low	Stream
PRSR55A	RIO JUEYES	55	S	PRSR55A		PRSR55A	RIO JUEYES	Low	Stream
				UCW--9					
PRSR56A	RIO CAYURES	56	S	PRSR56A		PRSR56A	RIO CAYURES	Low	Stream
PRSR57A	RIO COAMO	57	S	PRSR57A1		PRSR57A1	RIO COAMO	High	Stream
						PRSE57A	RIO COAMO	High	Estuarine
				PRSR57A2--1	PRSR57A2		RIO COAMO	High	Stream
				PRSR57A2--2					
				PRSR57B	PRSR57B		RIO CUYON	High	Stream
PRSR58A	RIO DESCALABRADO	58	S	PRSE58A		PRSE58A	RIO DESCALABRADO	Low	Estuarine
						PRSR58A	RIO DESCALABRADO	Low	Stream
PRSR59A	RIO CAÑAS	59	S	PRSR59A--2		PRSR59A	RIO CAÑAS	Low	Stream
PRSR62A	RIO BUCANA – CERRILLOS	62	S	PRSL62A1	PRSL62A		LAGO CERRILLOS	Medium	Lake
				PRSR62A1	PRSR62A1		RIO BUCANA-CERRILLOS	Medium	Stream
						PRSR62A2	RIO BUCANA-CERRILLOS	Medium	Stream

BASIN ID	BASIN NAME	BASIN SEQUENCE	REGION	TMDL ID	Assessment Unit ID: 303(d) listed of FC	Assessment Unit ID: not listed, impaired for FC	WATERBODY NAME	PRIORITY	TYPE
PRSR63A	RIO PORTUGUES	63	S	PRSR63A--1	PRSR63A		RIO PORTUGUES	Medium	Stream
				PRSR63A--2					
PRSR64A	RIO MATILDE – PASTILLO	64	S	PRSR64A--1	PRSE64A		RIO MATILDE-PASTILLO	Low	Estuarine
						PRSR64A	RIO MATILDE-PASTILLO	Low	Stream
				PRSR64A--2					
				PRSR59A--1					
PRSR65A	RIO TALLABOA	65	S	PRSR65A--1		PRSE65A	RIO TALLABOA	Low	Estuarine
						PRSR65A	RIO TALLABOA	Low	Stream
				PRSR65A--2					
PRSR66A	RIO MACANA	66	S	PRSR66A		PRSR66A	RIO MACANA	Low	Stream
						PRSE66A	RIO MACANA	Low	Estuarine
PRSQ38A	QUEBRADA MANGLILLO	38	S	UCW--17		PRSQ38A	QUEBRADA MANGLILLO	Low	Stream
PRSQ39A	QUEBRADA FLORIDA	39	S			PRSQ39A	QUEBRADA FLORIDA	Low	Stream
Rio Guamani to Rio Jacaboa Watersheds			S			unnamed	Coastal Watersheds East of Rio Jacaboa mouth		
PRSQ41A	QUEBRADA PALENQUE	41	S	UCW--15		PRSQ41A	QUEBRADA PALENQUE	Low	Stream
Rio Guamani to Rio Jacaboa Watersheds			S			unnamed	Coastal Watersheds West and East of Rio de Apeadero mouth		
PRSQ44A	QUEBRADA YAUREL	44	S	UCW--14		PRSQ44A	QUEBRADA YAUREL	Low	Stream
PRSQ50A	QUEBRADA MELANIA	50	S	UCW--8		PRSL50A	LAGO MELANIA	Medium	Lake
						PRSQ50A	Quebrada Melanía	Medium	Stream
						PRSE50A	Quebrada Melanía	Medium	Estuarine
PRSR70A	RIO ARROYO CAJUL	70	S	UCW--1		PRSR70A	RIO ARROYO CAJUL	Low	Stream
Quebrada Boqueron to Rio Loco Watersheds			S			unnamed	Coastal Watersheds South of Valle de Lajas		
Quebrada Boqueron to Rio Loco Watersheds			S	UCW--3		unnamed	Coastal Watersheds East of Rio Loco mouth		
Rio Coamo to Rio Seco Watersheds			S	UCW--11		unnamed	Coastal Watersheds West and East of Rio Jueyes mouth		
Rio Coamo to Rio Seco Watersheds			S	UCW--12		unnamed	Coastal Watersheds East of Rio Coamo mouth		
Rio Guamani to Rio Jacaboa Watersheds			S	UCW--18		unnamed	Coastal Watersheds West and East of Quebrada Branderi mouth		
Rio Guamani to Rio Jacaboa Watersheds			S	UCW--19		unnamed	Coastal Watersheds West and East of Quebrada Branderi mouth		
Rio Guamani to Rio Jacaboa Watersheds			S	UCW--20		unnamed	Coastal Watersheds West and East of Rio de Apeadero mouth		
Rio Matilde to Rio Descalabrado Watersheds			S	UCW--27		unnamed	Coastal Watersheds East of Rio Descalabrado		
Rio Matilde to Rio Descalabrado Watersheds			S	UCW--28		unnamed	Coastal Watersheds West and East of Rio Inabon mouth		
Rio Matilde to Rio Descalabrado Watersheds			S	UCW--29		unnamed	Coastal Watersheds East of Rio Matilde mouth		
Rio Matilde to Rio Descalabrado Watersheds			S	UCW--30		unnamed	Coastal Watersheds West and East of Rio Inabon mouth		
Rio Matilde to Rio Descalabrado Watersheds			S	UCW--31		unnamed	Coastal Watersheds West and East of Rio Canas mouth		
Rio Yauco to Rio Tallaboa Watersheds			S	UCW--36		unnamed	Coastal Watersheds South and North of Rio Yauco mouth		
Rio Yauco to Rio Tallaboa Watersheds			S	UCW--37		unnamed	Coastal Watersheds West and East of Rio Macana mouth		

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Rio Yauco to Rio Tallaboa Watersheds			S	UCW--38		unnamed	Coastal Watersheds West and East of Rio Macana mouth		
PRWQ71A	QUEBRADA BOQUERON	71	W	PRWQ71A	PRWQ71A		QUEBRADA BOQUERON	Medium	Stream
						PRWE71A	QUEBRADA BOQUERON	Medium	Estuarine
PRWR79A	RIO YAGÜEZ	79	W	PRWR79A	PRWR79A		RIO YAGÜEZ	High	Stream
						PRWE79A	RIO YAGÜEZ	High	Estuarine
PRWQ72A	QUEBRADA ZUMBON	72	W	UCW--24		PRWE72A	Quebrada Zumbón	Low	Stream
						PRWQ72A	Quebrada Zumbón	Low	Stream
PRWQ73A	QUEBRADA GONZALEZ	73	W			PRWE73A	Quebrada González	Low	Estuarine
						PRWQ73A	Quebrada González	Low	Stream
PRWQ74A	QUEBRADA LOS PAJARITOS	74	W			PRWE74A	Quebrada Pajaritos	Low	Estuarine
						PRWQ74A	Quebrada Pajaritos	Low	Stream
PRWK75A	CAÑO CONDE AVILA	75	W			PRWK75A	CAÑO Conde Ávila	Low	Stream
PRWQ76A	QUEBRADA IRIZARRY	76	W	UCW--22		PRWK76A	QUEBRADA IRIZARRY	Low	Stream
PRWK78A	CANO MERLE	78	W	UCW--23		PRWK78A	CAÑO MERLE	Low	Stream
						PRWE78A	CAÑO MERLE	Low	Estuarine
PRWK96A	CAÑO CORAZONES	96	W			PRWK96A	CAÑO CORAZONES	Low	Stream
PRWQ80A	QUEBRADA DEL ORO	80	W	UCW--34		PRWQ80A	QUEBRADA DEL ORO	Low	Stream
Quebrada Boqueron to Rio Loco Watersheds			W	UCW--2		unnamed	Coastal Watershed West of Quebrada Boqueron mouth		
RIO GUANAJIBO Watershed			W	UCW--21		PRWN0005	Laguna Joyudas		
PRWR92A	RIO GRANDE	92	W	PRWK93A		PRWE92A	RIO GRANDE	Low	Estuarine
PRWR92A	RIO GRANDE	92	W			PRWR92A	RIO GRANDE	Low	Stream
PRWK93A	CAÑO DE SANTI PONCE	93	W			PRWE93A	CAÑO DE SANTI PONCE	Low	Estuarine
PRWK93A	CAÑO DE SANTI PONCE	93	W			PRWK93A	CAÑO DE SANTI PONCE	Low	Estuarine
PRWR94A	RIO GUAYABO	94	W	PRWR94A	PRWE94A		RIO GUAYABO	Medium	Estuarine
PRWR94A	RIO GUAYABO	94	W		PRWR94A		RIO GUAYABO	Medium	Stream
PRNQ2A	QUEBRADA DEL TORO	2	N	UNC--3		PRNQ2A	QUEBRADA DEL TORO	Low	Stream
Quebrada Los Cedros to Rio Camuy Watersheds			N			unnamed	Non-contributing area - Name not assigned		
PRNR3A	RIO GUAJATACA	3	N	PRNL3A1		PRNL3A1	LAGO GUAJATACA	High	Lake
				PRNR3A1	PRNR3A1		RIO GUAJATACA	High	Stream
						PRNE3A	RIO GUAJATACA	High	Estuarine
				PRNR3A2	PRNR3A2		RIO GUAJATACA	High	Stream
				PRNQ3B	PRNQ3B		QUEBRADA LAS SEQUIAS	High	Stream
PRNQ4A	QUEBRADA BELLACA	4	N	UNC--2		PRNQ4A	QUEBRADA BELLACA	Low	Stream
						PRNE4A	QUEBRADA BELLACA	Low	Estuarine
PRNQ6A	QUEBRADA SECA	6	N			PRNQ6A	QUEBRADA SECA	Low	Stream
Quebrada Los Cedros to Rio Camuy Watersheds			N			unnamed	Non-contributing area - Name not assigned		

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PRNR5A	RIO CAMUY	5	N	PRNE5A		PRNE5A	RIO CAMUY	Low	Estuarine
				PRNR5A		PRNR5A	RIO CAMUY	Low	Stream
PRER11A	RIO HONDO	11	E	PRNR11A	PRER11A		RIO HONDO	High	Stream
PRER12A	RIO BAYAMON	12	E	PRELA2		PREL12A2	LAGO CIDRA	High	Lake
				PRER12A1	PRER12A1		RIO BAYAMÓN	High	Stream
				PRER12A2	PRER12A2		RIO BAYAMÓN	High	Stream
				PRER12B	PRER12B		RIO GUAYNABO	High	Stream
				PRER12C		PRER12C	RIO MINILLAS	High	Stream
PREE13A	SAN JUAN BAY ESTUARY SYSTEM	13	E	PREE13A1	PREE13A1		Caño Control de La Malaria; Bahía de San Juan; Caño San Antonio; Laguna Del Condado; & Península La Esperanza	Low	Estuarine
				PREE13A2	PREE13A2		Río Piedras & Lago Las Curías	Low	Estuarine
				PREE13A3	PREE13A3		Caño Martín Peña; Quebrada Juan Méndez; Quebrada San Antón; Quebrada Blasina; Canal Machicote; Canal Suárez; Laguna San José; Laguna Torrecillas; Laguna de Piñones; & Laguna Los Corozos	Low	Estuarine
PRER14A	RIO GRANDE DE LOIZA	14	E	PRER14A1	PRER14A1		RIO GRANDE DE LOIZA	High	Stream
				PRER14B	PRER14B		RIO CANOVANAS	High	Stream
				PRER14C	PRER14C		RIO CANOVANILLAS	High	Stream
				PREQ14D		PREQ14D	QUEBRADA MARACUTO	High	Stream
				PREQ14E		PREQ14E	QUEBRADA GRANDE	High	Stream
				URGL		unnamed	Unnamed		
PRER15A	RIO HERRERA	15	E	PREE15A	PREE15A		RIO HERRERA	Medium	Estuarine
					PRER15A		RIO HERRERA	Medium	Stream
PRER16A	RIO ESPIRITU SANTO	16	E	PREE16A	PRER16A		RIO ESPIRITU SANTO	Medium	Stream
					PREE16A		RIO ESPIRITU SANTO	Medium	Estuarine
PREE16.1	CAÑO RODRÍGUEZ		E	UCW--25		PREE16.1	CAÑO RODRÍGUEZ	Medium	Estuarine
Rio Herrera to Las Cabezas de San Juan Coastal Watersheds			E			unnamed	Coastal Watersheds between Rio Sabana and Rio Grande de Loiza		
PREQ18A	QUEBRADA MATA DE PLATANO	18	E		PREQ18A		Quebrada Mata de Plátano	Medium	Stream
PRER17A	RIO MAMEYES	17	E		PRER17A		RIO MAMEYES	Medium	Stream
				PREE17A		PREE17A	RIO MAMEYES	Medium	Estuarine

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PREQ36A	QUEBRADA EMAJAGUA	36	E	UCW--32	PREQ36A		QUEBRADA EMAJAGUA	Medium	Stream
Rio Maunabo to Rio Humacao Watersheds			E			unnamed	Coastal Watershed East of Rio Maunabo mouth		
Rio Maunabo to Rio Humacao Watersheds			E	UCW--33		unnamed	Coastal Watersheds North and South of Rio Candelero mouth		
SAN JUAN BAY ESTUARY Watershed			E	UCW--40		unnamed	Unnamed		
PRER33A	RIO HUMACAO	33	E	PREE33A	PREE33A		RIO HUMACAO	Medium	Estuarine
					PRER33A		RIO HUMACAO	Medium	Stream
PRER34A	RIO CANDELERO	34	E	PREE34A	PREE34A		RIO CANDELERO	Medium	Estuarine
					PRER34A		RIO CANDELERO	Medium	Stream
PRER35A	RIO GUAYANES	35	E	PREE35A	PREE35A		RIO GUAYANES	Medium	Estuarine
					PRER35A		RIO GUAYANES	Medium	Stream
PRER35.1 (PREK35.1)	CAÑO SANTIAGO			PREK35.1	PREE35.1		CAÑO SANTIAGO	Low	Estuarine
PRER37A	RIO MAUNABO	37	E	PRER37A	PRER37A		RIO MAUNABO	Medium	Stream
PRSQ46A	QUEBRADA SALADA	46	S	UCW--13		PRSE46A	QUEBRADA SALADA	Low	Estuarine
						PRSQ46A	QUEBRADA SALADA	Low	Stream
PRSQ52A	QUEBRADA AMOROS	52	S	UCW--10		PRSQ52A	QUEBRADA AMOROS	Medium	Stream
						PRSE52A	QUEBRADA AMOROS	Medium	Estuarine
PRSQ53A	QUEBRADA AGUAS VERDES	53	S	PRSE53A		PRSE53A	QUEBRADA AGUAS VERDES	Low	Estuarine
						PRSQ53A	QUEBRADA AGUAS VERDES	Low	Stream
PRSR54A	RIO NIGUAS – SALINAS	54	S	PRSR54A--1		PRSE54A	RIO NIGUAS DE SALINAS	Medium	Estuarine
				PRSR54A--2 PRSR54A--3 PRSR54A--4	PRSR54A		RIO NIGUAS DE SALINAS	Medium	Stream
PRSR60A	RIO JACAGUAS	60	S	PRSE60A		PRSE60A	RIO JACAGUAS	Low	Estuarine
						PRSR60A1	RIO JACAGUAS	Low	Stream
						PRSR60A2	RIO JACAGUAS	Low	Stream
				PRSL160A		PRSL(1)60A	LAGO GUAYABAL	Low	Lake
				PRSL260A		PRSL(2)60A	LAGO TOA VACA	Low	Lake
PRSR61A	RIO INABON	61	S	PRSR61A		PRSR61A	RIO INABON	Low	Stream
				PRSE61A		PRSE61A	RIO INABON	Low	Estuarine
PRSR67A	RIO GUAYANILLA	67	S	PRSR67A	PRSR67A		RIO GUAYANILLA	High	Stream

BASIN ID	BASIN NAME	BASIN SEQUENCE	REGION	TMDL ID	Assessment Unit ID: 303(d) listed of FC	Assessment Unit ID: not listed, impaired for FC	WATERBODY NAME	PRIORITY	TYPE
PRSR68A	RIO YAUCO	68	S	UCW--39 / PRSR68A		PRSE68A	RIO YAUCO	Low	Estuarine
				PRSR68A		PRSR68A1	RIO YAUCO	Low	Stream
				PRSR68A		PRSR68A2	RIO YAUCO	Low	Stream
				PRSL68A	PRSL68A1		LAGO LUCHETTI	Low	Lake
PRSR69A	RIO LOCO	69	S	2012 / PRSR69A1		PRSE69A	RIO LOCO	Medium	Estuarine
				PRSR69A1	PRSR69A2		RIO LOCO	Medium	Stream
				PRSR69A1		PRSN0024	Laguna Cartagena		
				PRSR69A1 / UVL-E / UVL-W	PRSR69A1		RIO LOCO	Medium	Stream
				PRSL69A	PRSL69A		LAGO LOCO	Medium	Lake
Rio Coamo to Rio Seco Watersheds			S	UCW--7		unnamed	Coastal Watersheds East of Rio Nigua mouth		
Rio Yauco to Rio Tallaboa Watersheds			S	UCW--35		PRSN0018	Laguna Salinas		
				UCW--35		unnamed	Coastal Watershed East of Rio Tallaboa mouth		
PRWR77A	RIO GUANAJIBO	77	W	PRWR77A		PRWE77A	RIO GUANAJIBO	High	Estuarine
				PRWR77A	PRWR77A		RIO GUANAJIBO	High	Stream
				PRWR77B		PRWR77B	RIO HONDO	High	Stream
				PRWR77C	PRWR77C		RIO ROSARIO	High	Stream
				PRWR77D		PRWR77D	RIO VIEJO	High	Stream
				PRWR77E	PRWR77E		RIO DUEY Y RIO HOCONUCO	High	Stream
				PRWR77F		PRWR77F	RIO CAIN	High	Stream
				PRWR77G		PRWR77G	RIO CUPEYES	High	Stream
				PRWR77H		PRWR77H	RIO CRUCES	High	Stream
				PRWR77I		PRWR77I	RIO GRANDE	High	Stream

2.2 Water Quality Criteria

Impaired waters classified as *SD* are subject to assessment methodologies and beneficial uses described in the *Rivers* category of Puerto Rico's section 303(d) list of impaired waters. Four beneficial use categories are identified here: Primary Contact Recreation (R1), Secondary Contact Recreation (R2), Aquatic Life (AL), and Drinking Water (DW).

Assessment units are identified in Table 2-1 as listed for fecal coliform bacteria impairments or unlisted but impaired for fecal coliform bacteria. Assessment units in Puerto Rico are defined by a watershed boundary, and are not the waterbody themselves.

An assessment unit contains a water body that is either impaired or not impaired, but the assessment unit itself includes both land and water components. These waters are designated as Class SD. None of the impaired assessment units fully support the designated uses of aquatic life or drinking water. While many of the assessment units support the designated use of secondary contact recreation, none fully support the designated use of primary contact recreation. The water quality standards that apply to these waters are as follows:

▪ Section 3.2.4.(A) of the Puerto Rico Water Quality Standards Regulations (PRWQSR) includes the following designated use for Class SD waters:

> "*Surface waters intended for use as raw water supply, propagation and preservation of desirable species, including threatened or endangered species, as well as primary and secondary contact recreation.*"

▪ Section 3.2.4(B)(2) of the PRWQSR, as amended in March 2003, includes the following criteria for coliform:

> "*<u>Coliforms</u>: The coliform geometric mean of a series of representative samples (at least five samples) of the water taken sequentially shall not exceed 10,000 colonies/100 mL of total coliforms or 200 colonies/100 mL of fecal coliforms. Not more than 20 percent of the samples shall exceed 400 colonies/100 mL of fecal coliforms.*"

The waterbodies listed in Table 2-1 are impaired for fecal coliform bacteria, so the numeric criteria described above will define the water quality target identified for determining the TMDL. Because the TMDL development approach uses a watershed model to compare fecal coliform bacteria concentrations against the water quality target, those streams that exhibit exceedances of the water quality targets are considered impaired by fecal coliform bacteria and will require TMDLs, even if they were not specifically listed in the 303(d) list. The watershed model shows fecal coliform exceeding water quality standards throughout the watershed for all evaluation units in Table 2-1.

2.3 Pollutant Sources

Potential sources that contribute fecal coliform bacteria can be grouped into two categories: point sources and nonpoint sources. Point sources include permitted discharges that were calculated on the basis of National Pollutant Discharge Elimination System (NPDES) limits for each facility and permitted stormwater under NPDES General Permit PRR040000 for Discharges from Small Municipal Separate Storm Sewer Systems (MS4). Nonpoint sources are diffuse and include watershed contributions (e.g., non-permitted stormwater runoff and septic contributions; estimated on the basis of population data) and local sources. Fecal coliform loading rates were obtained using information from EPA's Bacterial Indicator Tool (U.S. Environmental Protection Agency, 2001), which is a spreadsheet that estimates the bacteria contribution from multiple sources.

2.3.1 Point Sources

A point source, according to 40 CFR 122.3, is any discernible, confined, and discrete conveyance, including any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, and vessel or other floating craft from which pollutants are or could be discharged. The NPDES program, established under Clean Water Act Parts 318, 402, and 405, requires permits for the discharge of pollutants from point sources.

NPDES permit information was obtained from EPA's Permit Compliance System (PCS) and the Integrated Compliance Information System (ICIS) databases for permitted facilities in the target area. The data from PCS and ICIS include location, permit limits and discharge monitoring data for the active facilities, which were compiled and used to configure the Loading Simulation Program C++ (LSPC) model. For the locations of these facilities, see Figure 2-2, and for details on how point sources were accounted for in the TMDL, see Sections 4 and 5. Table 2-2 shows the permitted flows, permitted concentrations, and calculated fecal coliform bacteria loads for each permitted facility.

Table 2-2. Loads calculated based on present and permitted data from NPDES facilities (10/2007 to 9/2010)

Permit	Pipe	Facility Name	Assessment Unit ID	Present Avg Flow (cfs)	Permitted Flow (cfs)	Present Avg Conc (#/100 mL)	Permitted Conc (#/100 mL)	Permitted Load (#/yr)
PR0000477	5	RIMCO INC	PREE13A2	4.121		46,338.35	200	0.00E+00
PR0022411	1	PRASA WTP SERGIO CUEVAS	PREE13A3	294.639	4.250	10.00	200	7.59E+12
PR0022471	1	PRASA WTP GUZMAN ARRIBA	PREE16A	0.064	0.156	16.33	200	2.79E+11
PR0026379	1	PRASA - NE REGIONAL AQUEDUCT	PREE22A	1.162	0.920	2.00	200	1.64E+12
PR0022853	1	PRASA WTP NAGUABO	PREE29A	0.134	0.156	5.15	200	2.79E+11
PR0022829	1	PRASA WTP HUMACAO LAS PIEDRAS	PREE33A	0.189	0.526	4.00	200	9.39E+11
PR0001091	1	R.J. REYNOLDS TOBACCO (CI)	PREE35A		0.167		200	2.98E+11
PR0022799	1	PRASA WTP GUAYABOTA	PREE35A	0.014	0.046	57.09	200	8.29E+10
PR0025402	1	MARCOS SANCHEZ S.U. SCHOOL	PREE35A		0.019		400	6.63E+10
PR0021717	1	PRASA YABUCOA STP	PREK35.1	2.419	2.321	197.59	2000	4.15E+13
PR0022837	1	PRASA WTP YABUCOA	PREK35.1	0.145	0.074	10.14	200	1.33E+11
PR0025577	1	LA GLORIA WARD SCHOOL	PREQ14E	0.005	0.009	129.43	2000	1.66E+11
PR0022438	1	PRASA WTP GUAYNABO	PRER12A1	53.124	3.666	142.15	200	6.55E+12
PR0022543	1	PRASA - CIDRA WTP	PRER12A2	0.646	0.309	15.00	2000	5.53E+12
PR0022420	1	PRASA WTP CANOVANAS	PRER14B	1.263	2.475	390.00	NMR	NMR
PR0022462	1	PRASA WTP CUBUY	PRER14B	0.054	0.178	5,961.50	NMR	NMR
PR0025241	1	ESCUELA SECUNDARIA BARRIO CUBU	PRER14B	0.005	0.017	81.93	2000	2.96E+11
PR0020656	1	PRASA MAUNABO	PRER37A	0.963	1.547	411.86	200	2.76E+12
PR0026085	1	SUPERACUEDUCTO FILTRATION PLAN	PRNE7.1	20.803	10.829	328.00	200	1.93E+13
PR0025143	1	ESC AIBONITO BELTRAN	PRNL3A1	0.005	0.004	90.55	200	6.91E+09
PR0025721	1	PRASA - GUAJATACA WTP	PRNR3A1	0.421	0.464	1.00	200	8.29E+11
PR0025879	1	PRASA LARES	PRNR3A2	103.748	1.866	1.00	200	3.33E+12
PR0026450	1	PRASA LARES WTP	PRNR3A2	24.796	0.483	1.33	200	8.62E+11
PR0025852	1	PRASA REAL ANON FILTER PLANT	PRSE61A	recircula	0.067		200	1.19E+11
PR0025526	1	PRASA PATILLAS WTP	PRSL43A1	0.093	0.579	0.09	NMR	NMR
PR0020753	1	PRASA PATILLAS	PRSR42A	69.369	1.702	14,906.53	200	3.04E+12
PR0022594	1	PRASA WTP MATUYAS FILTER PLANT	PRSR42A	0.032	0.045	24.90	200	7.96E+10
PR0023094	1	ELEM & INTER SCHOOL	PRSR45A	0.003	0.023	347.61	2000	4.14E+11
PR0022764	1	PRASA WTP COAMO FILTER PLANT	PRSR57A2--1	recircula	0.223		200	3.98E+11
PR0025569	1	CUYON WARD SCHOOL	PRSR57B	0.009	0.022	285.50	2000	3.87E+11
PR0026093	1	RAMOS & MORALES ACADEMY	PRSR59A--1	0.015	0.093	127.28	200	1.66E+11

Permit	Pipe	Facility Name	Assessment Unit ID	Present Avg Flow (cfs)	Permitted Flow (cfs)	Present Avg Conc (#/100 mL)	Permitted Conc (#/100 mL)	Permitted Load (#/yr)
PR0022781	1	PRASA WTP PTA VIEJA PONCE	PRSR63A--1	0.381	0.396	5.00	2000	7.07E+12
PR0024651	1	PRASA GUARAGUAO	PRSR63A--2	0.006	0.009	77.00	2000	1.66E+11
PR0025844	2	BFI OF PONCE	PRSR64A--2					0.00E+00
PR0020761	1	PRASA PENUELAS	PRSR65A--1	0.661	1.160	466.93	200	2.07E+12
PR0025666	5	GULF CHEMICAL CORPORATION	PRSR65A--1				2000	0.00E+00
PR0025798	1	PRASA - RUCIO WTP	PRSR65A--1	recircula	0.045	31.00	200	7.99E+10
PR0026395	1	PRASA MAL PASO WTP	PRSR65A--2	0.032	0.028	6.36	200	4.97E+10
PR0020494	1	PRASA GUAYANILLA	PRSR67A	0.683	0.959	2,282.21	200	1.71E+12
PR0024678	1	PRASA JAGUA-PASTO FILTER PLNT	PRSR67A	0.067	0.111	1.67	200	1.99E+11
PR0021661	1	PRASA YAUCO STP	PRSR68A	2.721	3.200	402.41	200	5.71E+12
PR0020818	1	PRASA SAN GERMAN	PRWR77A	383.571	12.376	1,806.50	200	2.21E+13
PR0022977	1	PRASA WTP SAN GERMAN	PRWR77A	0.334	0.252	2.00	NMR	NMR
PR0024007	1	PRASA WTP SABANA GRANDE	PRWR77A	0.106	0.111	8.50	NMR	NMR
PR0025542	1	PRASA SABANA GRANDE STP	PRWR77A	1.707	1.547	3,032.26	200	2.76E+12
PR0020648	1	PRASA MARICAO	PRWR77C	0.213	0.271	7,360.78	2000	4.84E+12
PR0022969	1	PRASA WTP MARICAO FILTER PLANT	PRWR77C	0.090	0.367	1.67	2000	6.56E+12
PR0026204	1	PRASA - CAIN ALTO WTP	PRWR77F	0.026	0.048	6.23	200	8.57E+10
PR0026131	1	PRASA - LA MAQUINA WTP	PRWR77H	0.127	0.033	1.67	200	5.97E+10
PR0022900	1	PRASA WTP MAYAGUEZ FILTER PLT	PRWR79A	0.539	0.907	1.67	2000	1.62E+13
PR0023264	1	PRASA RIO GRANDE ESTATES	UCW--25	1.758	1.160	860.63	200	2.07E+12
PR0023931	1	PRASA EL YUNQUE FILTRATION PLT	UCW--25	70.529	3.403	874.00	2000	6.08E+13
PR0026425	1	COCO BEACH WTP	UCW--25		1.547		2000	2.76E+13
PR0000493	1	TROPICAL CITY INDUSTRIES INC	UCW--29				400	0.00E+00
PR0023990	1	PRASA WTP MIRADERO FILTER PLT	UCW--34	159.522	2.231	10.00	200	3.98E+12
PR0025313	1	SILVERIO GARCIS CLARA WARD SCHOOL	UCW--4	0.011	0.019	171.14	200	3.32E+10
PR0020010	1	U.S. NAVAL STA.	UCW--5	0.314	1.450	18.87	2000	2.59E+13
PR0020010	2	U.S. NAVAL STA.	UCW--5	0.205	1.748	20.00	2000	3.12E+13
PR0020010	4	U.S. NAVAL STA.	UCW--5	0.273	1.013	19.45	2000	1.81E+13
PR0024163	1	PRASA WTP HATILLO	UNC--2	0.147	0.099	1.61	200	1.77E+11
PR0022918	1	PRASA WTP AGUADILLA FILTER PLT	UNC--3	0.387	2.942	25.67	200	5.26E+12
PR0024015	1	PRASA WTP RAMEY PLANT	UNC--3	0.157	0.134	10.83	200	2.39E+11
PR0020575	1	PRASA LAJAS	UVL-E	0.921	1.856	1,728.86	200	3.32E+12
PR0023159	1	ELEM & INTER SCHOOL	PRWR94A		0.015		400	5.53E+10

*Note : Scientific notation was used to display the #/day of fecal coliform bacteria, this is a way of writing numbers that accommodates values too large or small to be conveniently written in standard decimal notation. The letter E represents times ten raised to the power noted. To know the given value: after the point add the quantity of zeros to complete the number of spaces determined by the number at the right of the letter "E". Example: 1.11E+13 = 11,100,000,000,000. This applies, anywhere that a value of this type appears.
"NMR" = no monitoring required (for fecal coliform).
"recircula" = effluent is recirculated

Runoff from *urbanized areas* (UAs)[1] as defined by the U.S. Bureau of the Census is defined as a point source discharge, while runoff from urban areas outside the Census UAs is considered a nonpoint source discharge. Geographical information system (GIS) coverage of UAs from the 2000 Census was used to separate the urban areas into municipal separate storm sewer systems (MS4s) and non-MS4 urban areas. Table 2-3 presents the estimated fecal coliform bacteria loads from MS4 areas in the target watersheds. The estimated fecal coliform bacteria loads from MS4 areas were calculated based on the unit area load of fecal coliform bacteria for the urban landuses from the LSPC model, and applied to the urban areas within the UAs defined by the census.

[1] http://cfpub.epa.gov/npdes/stormwater/urbanmapresult.cfm?state=PR

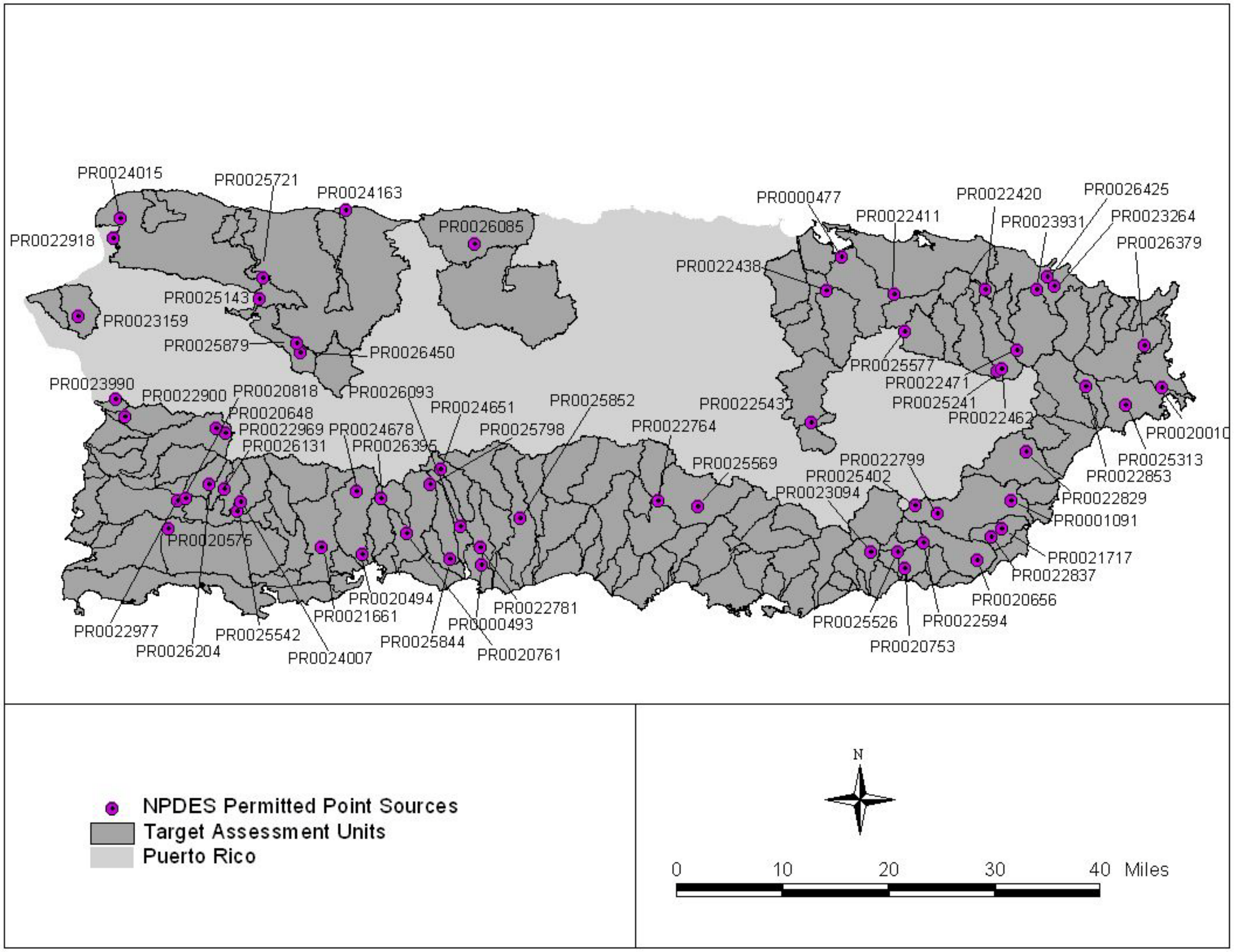

Figure 2-2. Permitted facilities in the target watersheds.

Table 2-3. Estimated fecal coliform bacteria loads for MS4 areas.

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)
San Juan, PR	Bayamon	79093	PREE13A1	2.8232E+16
San Juan, PR	Catano	79093	PREE13A1	8.0042E+16
San Juan, PR	Guaynabo	79093	PREE13A1	4.5997E+16
San Juan, PR	San Juan	79093	PREE13A1	1.6105E+16
San Juan, PR	Toa Baja	79093	PREE13A1	6.9348E+15
San Juan, PR	Guaynabo	79093	PREE13A2	4.6804E+16
San Juan, PR	San Juan	79093	PREE13A2	3.0620E+17
San Juan, PR	Trujillo Alto	79093	PREE13A2	1.1934E+16
San Juan, PR	Canovanas	79093	PREE13A3	7.2127E+11
San Juan, PR	Carolina	79093	PREE13A3	3.0853E+17
San Juan, PR	Loiza	79093	PREE13A3	1.0587E+15
San Juan, PR	San Juan	79093	PREE13A3	4.0020E+17
San Juan, PR	Trujillo Alto	79093	PREE13A3	1.7645E+16
San Juan, PR	Canovanas	79093	PREE15A	5.4164E+14
San Juan, PR	Loiza	79093	PREE15A	2.9216E+14
San Juan, PR	Rio Grande	79093	PREE15A	7.7682E+15
San Juan, PR	Rio Grande	79093	PREE16A	6.6943E+15
Fajardo, PR	Luquillo	28981	PREE17A	5.7913E+13
San Juan, PR	Rio Grande	79093	PREE17A	1.8355E+15
Fajardo, PR	Luquillo	28981	PREE19A	7.4749E+15
Fajardo, PR	Fajardo	28981	PREE20A	4.0403E+12
Fajardo, PR	Luquillo	28981	PREE20A	8.9222E+14
Fajardo, PR	Ceiba	28981	PREE22A	6.4964E+12
Fajardo, PR	Fajardo	28981	PREE22A	3.7408E+16
San Juan, PR	Naguabo	79093	PREE29A	4.7626E+15
San Juan, PR	Humacao	79093	PREE31A	3.3257E+15
San Juan, PR	Las Piedras	79093	PREE31A	1.5667E+12
San Juan, PR	Naguabo	79093	PREE31A	1.1062E+11
San Juan, PR	Humacao	79093	PREE33A	6.5159E+16
San Juan, PR	Las Piedras	79093	PREE33A	1.6633E+14
San Juan, PR	Yabucoa	79093	PREE33A	2.1935E+11
San Juan, PR	Humacao	79093	PREE34A	1.3271E+16
San Juan, PR	Yabucoa	79093	PREE34A	7.0919E+11
San Juan, PR	Humacao	79093	PREE35A	1.7927E+11
San Juan, PR	Las Piedras	79093	PREE35A	2.3727E+10
San Juan, PR	San Lorenzo	79093	PREE35A	2.6982E+11
San Juan, PR	Yabucoa	79093	PREE35A	8.0495E+15
San Juan, PR	Maunabo	79093	PREK35.1	5.2728E+09
San Juan, PR	Yabucoa	79093	PREK35.1	1.2082E+16
San Juan, PR	Aguas Buenas	79093	PRELA2	8.3086E+08
San Juan, PR	Caguas	79093	PRELA2	4.2499E+11
San Juan, PR	Cidra	79093	PRELA2	1.4106E+13
San Juan, PR	Carolina	79093	PREQ14D	2.2436E+15
San Juan, PR	Gurabo	79093	PREQ14D	1.7983E+11
San Juan, PR	Trujillo Alto	79093	PREQ14D	6.8905E+12
San Juan, PR	Carolina	79093	PREQ14E	7.2365E+10

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)
San Juan, PR	Gurabo	79093	PREQ14E	1.1827E+13
San Juan, PR	Trujillo Alto	79093	PREQ14E	1.4006E+15
Fajardo, PR	Fajardo	28981	PREQ21A	4.0221E+16
Fajardo, PR	Luquillo	28981	PREQ21A	1.3784E+12
San Juan, PR	Humacao	79093	PREQ30B	2.2888E+11
San Juan, PR	Naguabo	79093	PREQ30B	1.5543E+15
San Juan, PR	Bayamon	79093	PRER12A1	9.6220E+13
San Juan, PR	Catano	79093	PRER12A1	2.5933E+10
San Juan, PR	Guaynabo	79093	PRER12A1	3.5949E+13
San Juan, PR	Toa Baja	79093	PRER12A1	1.0170E+10
San Juan, PR	Aguas Buenas	79093	PRER12A2	1.1612E+13
San Juan, PR	Bayamon	79093	PRER12A2	1.1112E+12
San Juan, PR	Cidra	79093	PRER12A2	1.7954E+12
San Juan, PR	Comerio	79093	PRER12A2	2.7465E+10
San Juan, PR	Guaynabo	79093	PRER12A2	6.4406E+11
San Juan, PR	Aguas Buenas	79093	PRER12B	2.4008E+12
San Juan, PR	Bayamon	79093	PRER12B	1.2134E+10
San Juan, PR	Guaynabo	79093	PRER12B	1.3357E+14
San Juan, PR	San Juan	79093	PRER12B	4.1195E+13
San Juan, PR	Bayamon	79093	PRER12C	4.8613E+13
San Juan, PR	Canovanas	79093	PRER14A1	8.6742E+15
San Juan, PR	Carolina	79093	PRER14A1	5.0824E+16
San Juan, PR	San Juan	79093	PRER14A1	4.4657E+13
San Juan, PR	Trujillo Alto	79093	PRER14A1	1.2562E+16
San Juan, PR	Canovanas	79093	PRER14B	2.3843E+15
San Juan, PR	Rio Grande	79093	PRER14B	9.4442E+13
San Juan, PR	Canovanas	79093	PRER14C	9.3005E+15
San Juan, PR	Carolina	79093	PRER14C	8.4987E+15
San Juan, PR	Juncos	79093	PRER14C	1.9585E+10
Fajardo, PR	Luquillo	28981	PRER19A	5.0039E+15
San Juan, PR	Naguabo	79093	PRER30A	1.3346E+16
San Juan, PR	Maunabo	79093	PRER37A	8.5804E+15
San Juan, PR	Yabucoa	79093	PRER37A	5.2728E+09
Aguadilla--Isabela--San Sebastian, PR	Camuy	00631	PRNE5A	1.1076E+11
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	PRNE5A	3.0662E+09
Arecibo, PR	Camuy	03034	PRNE5A	4.9926E+11
Arecibo, PR	Hatillo	03034	PRNE5A	7.8661E+11
Arecibo, PR	Arecibo	03034	PRNE7.1	3.4148E+11
Arecibo, PR	Barceloneta	03034	PRNE7.1	1.6263E+11
Florida--Barceloneta--Bajadero, PR	Arecibo	30115	PRNE7.1	2.2323E+12
Florida--Barceloneta--Bajadero, PR	Barceloneta	30115	PRNE7.1	5.1246E+11
Aguadilla--Isabela--San Sebastian, PR	Isabela	00631	PRNL3A1	3.0474E+09
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	PRNL3A1	4.8758E+09
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	PRNL3A1	2.5565E+11
Arecibo, PR	Camuy	03034	PRNL3A1	1.5899E+08
Arecibo, PR	Quebradillas	03034	PRNL3A1	8.3471E+09
Aguadilla--Isabela--San Sebastian, PR	Aguadilla	00631	PRNQ1A	3.5069E+11

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)
Aguadilla--Isabela--San Sebastian, PR	Isabela	00631	PRNQ1A	1.4458E+11
Aguadilla--Isabela--San Sebastian, PR	Isabela	00631	PRNQ3B	1.4207E+11
San Juan, PR	Bayamon	79093	PRNR11A	3.4768E+14
San Juan, PR	Catano	79093	PRNR11A	2.8269E+12
San Juan, PR	Toa Alta	79093	PRNR11A	1.7115E+11
San Juan, PR	Toa Baja	79093	PRNR11A	2.8813E+13
Aguadilla--Isabela--San Sebastian, PR	Isabela	00631	PRNR3A1	5.6544E+10
Aguadilla--Isabela--San Sebastian, PR	Quebradillas	00631	PRNR3A1	7.1547E+08
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	PRNR3A1	5.1531E+07
Arecibo, PR	Quebradillas	03034	PRNR3A1	1.6167E+11
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	PRNR3A2	8.4670E+11
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	PRNR3A2	1.4751E+11
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	PRNR5A	2.9827E+11
Aguadilla--Isabela--San Sebastian, PR	Utuado	00631	PRNR5A	1.8130E+11
Guayama, PR	Guayama	35866	PRSE48A	1.9629E+16
Guayama, PR	Guayama	35866	PRSE51A	1.3323E+10
Guayama, PR	Salinas	35866	PRSE53A	1.1042E+11
Juana Diaz, PR	Juana Diaz	43453	PRSE60A	4.6902E+11
Juana Diaz, PR	Villalba	43453	PRSE60A	1.8889E+10
Ponce, PR	Juana Diaz	70642	PRSE60A	2.3378E+10
Ponce, PR	Ponce	70642	PRSE60A	3.6862E+09
Juana Diaz, PR	Juana Diaz	43453	PRSE61A	4.5384E+09
Ponce, PR	Juana Diaz	70642	PRSE61A	2.1401E+10
Ponce, PR	Ponce	70642	PRSE61A	4.6400E+11
Yauco, PR	Guanica	97561	PRSE69A	1.9317E+11
Juana Diaz, PR	Juana Diaz	43453	PRSL160A	1.4350E+10
Juana Diaz, PR	Villalba	43453	PRSL160A	8.7778E+11
Juana Diaz, PR	Villalba	43453	PRSL260A	6.7910E+10
San Juan, PR	Coamo	79093	PRSL260A	7.2363E+10
San Juan, PR	Orocovis	79093	PRSL260A	3.9242E+09
Guayama, PR	Patillas	35866	PRSL43A1	2.1351E+12
Yauco, PR	Yauco	97561	PRSL68A	1.1986E+10
Yauco, PR	Yauco	97561	PRSL69A	1.0015E+11
San Juan, PR	Patillas	79093	PRSR40A	5.6585E+09
Guayama, PR	Patillas	35866	PRSR42A	4.5019E+15
Guayama, PR	Patillas	35866	PRSR43A1	8.8799E+14
Guayama, PR	Patillas	35866	PRSR43B	1.1567E+12
Guayama, PR	Arroyo	35866	PRSR45A	3.8711E+15
Guayama, PR	Guayama	35866	PRSR47A	2.1348E+15
Guayama, PR	Guayama	35866	PRSR49A	1.1120E+16
San Juan, PR	Cayey	79093	PRSR54A--2	1.7758E+09
San Juan, PR	Salinas	79093	PRSR54A--2	1.5914E+10
San Juan, PR	Cayey	79093	PRSR54A--3	1.7357E+09
San Juan, PR	Cayey	79093	PRSR54A--4	2.3997E+10
San Juan, PR	Salinas	79093	PRSR54A--4	8.0151E+10
San Juan, PR	Barranquitas	79093	PRSR57A2--1	1.7808E+08
San Juan, PR	Coamo	79093	PRSR57A2--1	1.5384E+09

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)
San Juan, PR	Orocovis	79093	PRSR57A2--1	1.2366E+08
San Juan, PR	Aibonito	79093	PRSR57B	1.4093E+10
San Juan, PR	Coamo	79093	PRSR57B	1.1377E+08
Ponce, PR	Ponce	70642	PRSR59A--1	5.4971E+11
Juana Diaz, PR	Juana Diaz	43453	PRSR59A--2	9.1185E+10
Juana Diaz, PR	Juana Diaz	43453	PRSR61A	9.6559E+10
Juana Diaz, PR	Villalba	43453	PRSR61A	5.9528E+07
Ponce, PR	Ponce	70642	PRSR62A1	7.6539E+11
Ponce, PR	Ponce	70642	PRSR63A--1	1.2486E+12
Ponce, PR	Ponce	70642	PRSR63A--2	9.1102E+08
Ponce, PR	Ponce	70642	PRSR64A--1	4.7495E+11
Yauco, PR	Penuelas	97561	PRSR64A--1	2.2763E+07
Ponce, PR	Ponce	70642	PRSR64A--2	6.3459E+11
Yauco, PR	Penuelas	97561	PRSR65A--1	4.0859E+11
Yauco, PR	Penuelas	97561	PRSR65A--2	2.1995E+11
Yauco, PR	Guayanilla	97561	PRSR66A	1.5519E+11
Yauco, PR	Penuelas	97561	PRSR66A	1.1469E+11
Yauco, PR	Guayanilla	97561	PRSR67A	4.8707E+11
Yauco, PR	Yauco	97561	PRSR67A	2.5338E+10
Yauco, PR	Guayanilla	97561	PRSR68A	5.3730E+09
Yauco, PR	Yauco	97561	PRSR68A	8.9816E+11
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRSR69A1	7.1596E+09
Yauco, PR	Guanica	97561	PRSR69A1	1.3371E+11
Yauco, PR	Sabana Grande	97561	PRSR69A1	5.7077E+09
Yauco, PR	Yauco	97561	PRSR69A1	4.4996E+11
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	PRWQ71A	3.1013E+11
Mayaguez, PR	Hormigueros	55738	PRWR77A	6.5504E+11
Mayaguez, PR	Mayaguez	55738	PRWR77A	1.1394E+09
Mayaguez, PR	San German	55738	PRWR77A	4.1398E+10
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	PRWR77A	3.4347E+10
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRWR77A	7.4426E+11
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77A	1.1590E+12
Mayaguez, PR	Hormigueros	55738	PRWR77B	9.3779E+10
Mayaguez, PR	Mayaguez	55738	PRWR77B	5.5631E+11
Mayaguez, PR	Hormigueros	55738	PRWR77C	1.0299E+11
Mayaguez, PR	Mayaguez	55738	PRWR77C	3.4723E+10
Mayaguez, PR	San German	55738	PRWR77C	5.5434E+10
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	PRWR77D	8.3865E+11
San German--Cabo Rojo--Sabana Grande, PR	Lajas	78985	PRWR77D	5.5291E+08
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77D	3.4163E+11
Mayaguez, PR	San German	55738	PRWR77E	2.1799E+11
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77E	1.9736E+11
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77F	4.7668E+11
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRWR77G	1.6488E+08
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77G	1.1602E+11
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRWR77H	2.7417E+11
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77H	3.5509E+10

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRWR77I	2.2530E+11
Mayaguez, PR	Mayaguez	55738	PRWR79A	1.3698E+12
San German--Cabo Rojo--Sabana Grande, PR	Lajas	78985	UCW--1	1.2564E+09
Yauco, PR	Guanica	97561	UCW--1	1.6757E+11
Yauco, PR	Lajas	97561	UCW--1	1.9005E+08
Guayama, PR	Guayama	35866	UCW--10	9.8859E+09
Guayama, PR	Salinas	35866	UCW--10	7.2992E+09
Guayama, PR	Arroyo	35866	UCW--13	7.3253E+15
Guayama, PR	Guayama	35866	UCW--13	7.5270E+14
Guayama, PR	Arroyo	35866	UCW--14	7.1689E+15
Guayama, PR	Patillas	35866	UCW--14	1.3249E+14
Guayama, PR	Patillas	35866	UCW--15	5.1804E+14
San Juan, PR	Patillas	79093	UCW--17	5.0657E+14
Guayama, PR	Guayama	35866	UCW--18	3.2374E+15
Guayama, PR	Guayama	35866	UCW--19	6.7902E+10
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	UCW--2	9.5993E+10
Guayama, PR	Patillas	35866	UCW--20	3.7348E+11
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	UCW--21	4.8629E+10
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	UCW--22	1.8975E+10
Mayaguez, PR	Mayaguez	55738	UCW--23	1.9656E+12
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	UCW--24	6.3560E+11
Fajardo, PR	Luquillo	28981	UCW--25	1.8050E+16
San Juan, PR	Canovanas	79093	UCW--25	1.6210E+16
San Juan, PR	Loiza	79093	UCW--25	4.9594E+16
San Juan, PR	Rio Grande	79093	UCW--25	5.5924E+16
Fajardo, PR	Luquillo	28981	UCW--26	1.1427E+11
Ponce, PR	Ponce	70642	UCW--28	1.9789E+11
Ponce, PR	Ponce	70642	UCW--29	3.7719E+12
Yauco, PR	Guanica	97561	UCW--3	5.8134E+10
Ponce, PR	Juana Diaz	70642	UCW--30	7.8537E+10
Ponce, PR	Ponce	70642	UCW--30	2.6142E+10
Juana Diaz, PR	Juana Diaz	43453	UCW--31	3.0201E+10
Ponce, PR	Juana Diaz	70642	UCW--31	1.3447E+11
San Juan, PR	Maunabo	79093	UCW--32	1.9507E+15
San Juan, PR	Yabucoa	79093	UCW--32	1.2356E+15
San Juan, PR	Humacao	79093	UCW--33	4.1985E+15
San Juan, PR	Yabucoa	79093	UCW--33	5.2616E+14
Mayaguez, PR	Mayaguez	55738	UCW--34	7.1452E+11
Ponce, PR	Penuelas	70642	UCW--35	7.7850E+10
Ponce, PR	Ponce	70642	UCW--35	4.6588E+11
Yauco, PR	Guayanilla	97561	UCW--36	6.4486E+10
Yauco, PR	Penuelas	97561	UCW--37	1.1041E+08
Yauco, PR	Guayanilla	97561	UCW--38	1.3284E+11
Fajardo, PR	Ceiba	28981	UCW--4	2.5244E+16
Fajardo, PR	Naguabo	28981	UCW--4	5.5730E+15
San Juan, PR	Naguabo	79093	UCW--4	5.5698E+15
San Juan, PR	San Juan	79093	UCW--40	2.4711E+16

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)
Fajardo, PR	Ceiba	28981	UCW--5	1.4559E+16
Fajardo, PR	Fajardo	28981	UCW--5	1.4645E+16
San Juan, PR	Humacao	79093	UCW--6	4.0716E+16
San Juan, PR	Naguabo	79093	UCW--6	3.4957E+13
Guayama, PR	Salinas	35866	UCW--7	5.6809E+10
Guayama, PR	Guayama	35866	UCW--8	1.7186E+11
Florida--Barceloneta--Bajadero, PR	Arecibo	30115	UNC--1	4.9932E+11
Florida--Barceloneta--Bajadero, PR	Barceloneta	30115	UNC--1	3.2525E+11
Florida--Barceloneta--Bajadero, PR	Florida	30115	UNC--1	4.1203E+11
Florida--Barceloneta--Bajadero, PR	Manati	30115	UNC--1	9.4907E+10
San Juan, PR	Ciales	79093	UNC--1	6.8358E+10
San Juan, PR	Manati	79093	UNC--1	2.7219E+10
Aguadilla--Isabela--San Sebastian, PR	Camuy	00631	UNC--2	1.0566E+11
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	UNC--2	6.7823E+11
Aguadilla--Isabela--San Sebastian, PR	Quebradillas	00631	UNC--2	3.5041E+09
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	UNC--2	1.4429E+09
Arecibo, PR	Arecibo	03034	UNC--2	4.0472E+12
Arecibo, PR	Camuy	03034	UNC--2	2.2898E+12
Arecibo, PR	Hatillo	03034	UNC--2	3.8473E+12
Arecibo, PR	Quebradillas	03034	UNC--2	2.0029E+12
Aguadilla--Isabela--San Sebastian, PR	Aguadilla	00631	UNC--3	3.8598E+12
Aguadilla--Isabela--San Sebastian, PR	Isabela	00631	UNC--3	3.0454E+12
Aguadilla--Isabela--San Sebastian, PR	Moca	00631	UNC--3	2.7881E+11
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	UNC--3	2.1918E+10
San Juan, PR	Canovanas	79093	URGL	2.9683E+16
San Juan, PR	Loiza	79093	URGL	7.3358E+15
San German--Cabo Rojo--Sabana Grande, PR	Lajas	78985	UVL-E	6.6462E+11
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	UVL-E	3.1961E+11
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	UVL-E	2.3573E+10
Yauco, PR	Guanica	97561	UVL-E	1.0420E+11
Yauco, PR	Lajas	97561	UVL-E	1.2903E+10
Yauco, PR	Sabana Grande	97561	UVL-E	1.1767E+11
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	UVL-W	1.4974E+11
San German--Cabo Rojo--Sabana Grande, PR	Lajas	78985	UVL-W	1.4445E+11
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	UVL-W	2.6234E+10
Anasco	Anasco	72011	PRWR94A	1.6015E+08
Aguada	Aguada	72003	PRWR94A	1.6123E+12
Rincon	Rincon	72117	PRWR94A	6.9826E+10
Aguada	Aguada	72003	PRWK93A	1.8194E+11
Rincon	Rincon	72117	PRWK93A	4.0348E+11
			Total Load:	**1.9826E+18**

2.3.2 Nonpoint Sources

Nonpoint sources are considered diffuse sources of pollution. They can contribute to a waterbody because of rainfall-runoff processes or diffusely during dry conditions. The following subsections describe potential sources of fecal coliform bacteria to the target watersheds and identify likely contributors. These sources are ultimately used as the basis for load estimation and TMDL determination.

2.3.2.1 Agriculture

Agricultural land, which typically consists of cropland, pastureland, and refined animal management, represents significant percentage of the total watershed acreage. Land use data from the year 2000 was obtained by associating the classified land cover distribution determined using an ERDAS Imagine[2] imagery by the International Institute of Tropical Forestry (IITF) into land use areas which classifies 32,022 acres as agricultural land and 455,875 acres as pasture (see Table 4-1). This acreage represents 38.1 percent of the watershed and likely has a significant impact on fecal coliform bacteria levels downstream. Table 2-4 shows the total number of confined animal operations by assessment unit, and Figure 2-3 shows the locations of CAFOs.

The accumulation rate of fecal coliform bacteria on agricultural lands and pastures was estimated using EPA's Bacteria Indicator Tool. This tool provides an average fecal bacteria load for each animal type per day. The total number of animals multiplied by the loading per animal per day gave an estimate of fecal bacteria load per day. Dividing this load by the corresponding landuse area (either pastures or agriculture) for those subbasins where the facilities are located, a loading rate per acre was calculated. This analysis was done separately by CAFO facility and summarized by region for use in the model (see Appendix E).

2.3.2.2 Non-Permitted Urban Runoff

Urban areas are generally characterized by higher percentages of impervious land because of cover of the land surface by pavement, concrete, and buildings. Higher percentages of impervious area, if not properly managed, result in higher surface runoff potential because of the reduced ability of water to infiltrate into the ground during rainfall events. As water runs over the land and paved surfaces, debris and pollutants such as fecal coliform bacteria are entrained and subsequently flow into storm drains and ditches, which lead to local coastal waterbodies. Harmful bacteria and viruses from pet wastes carried by urban runoff to a waterbody can contribute to shellfish contamination, harm other aquatic life, and threaten human health. Studies have shown that fecal coliform bacteria levels are typically high in urban runoff (USEPA 2001) and, thus, can be a significant source of pollution in the target watersheds.

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[2] ERDAS Imagine imagery is a specific format of geospatial imagery. The imagery used was provided by the International Institute of Tropical Forestry (IITF). IITF's work is documented in the following reference:

Helmer, E.H., O. Ramos, T. del Mar Lopez, M. Quiñones,and W. Diaz. 2002. *Mapping forest type and land cover of Puerto Rico, a component of the Caribbean biodiversity hotspot.* Caribbean Journal of Science 38:165-183.

Table 2-4. Livestock operations in the study area.

Assessment Unit	# CAFOs	Assessment Unit	# CAFOs	Assessment Unit	# CAFOs
PREE13A1	1	PRER12C	1	PRNQ1A	3
PREE13A2	3	PRER14A1	4	PRNQ3B	3
PREE13A3	3	PRER14B	1	PRNR3A2	10
PREE15A	1	PRER14C	2	PRNR5A	2
PREE16A	3	PRER19A	2	PRSE53A	4
PREE17A	14	PRER30A	5	PRSE58A	2
PREE19A	3	PRNE5A	8	PRSL160A	2
PREE22A	5	PRNE7.1	11	PRSR49A	2
PREE29A	2	PRNL3A1	6	PRSR54A	3
PREE31A	3	UCW--31	1	PRSR55A	1
PREE33A	1	UCW--4	9	PRSR57A2	9
PREE34A	1	UCW--5	1	PRSR57B	18
PREE35A	2	UCW--6	2	PRSR64A	1
PRELA2	1	UNC--1	27	PRWR77D	1
PREQ14D	7	UNC--2	122	PRWR77F	1
PREQ14E	11	UNC--3	21	PRWR79A	2
PREQ30B	5	URGL	1	PRER12B	1
PRER12A1	2	UVL-E	9	UCW--25	2
PRER12A2	2	UVL-W	1	**Total # of CAFOs:**	**371**

EPA's Bacteria Indicator Tool includes fecal coliform accumulation rates for single family low density residential, single family high density residential, and multifamily residential landuses. We estimated the modeled low/medium density residential landuse accumulation rate as the average of both single family low density and single family high density residential. We also estimated the medium/high density residential landuse accumulation rate as the average of both single family high density and multifamily residential, as shown on Table 2-5. Table 2-6 presents the estimated fecal coliform bacteria loads from nonpermitted stormwater by Assessment Unit and landuse type for the target watersheds.

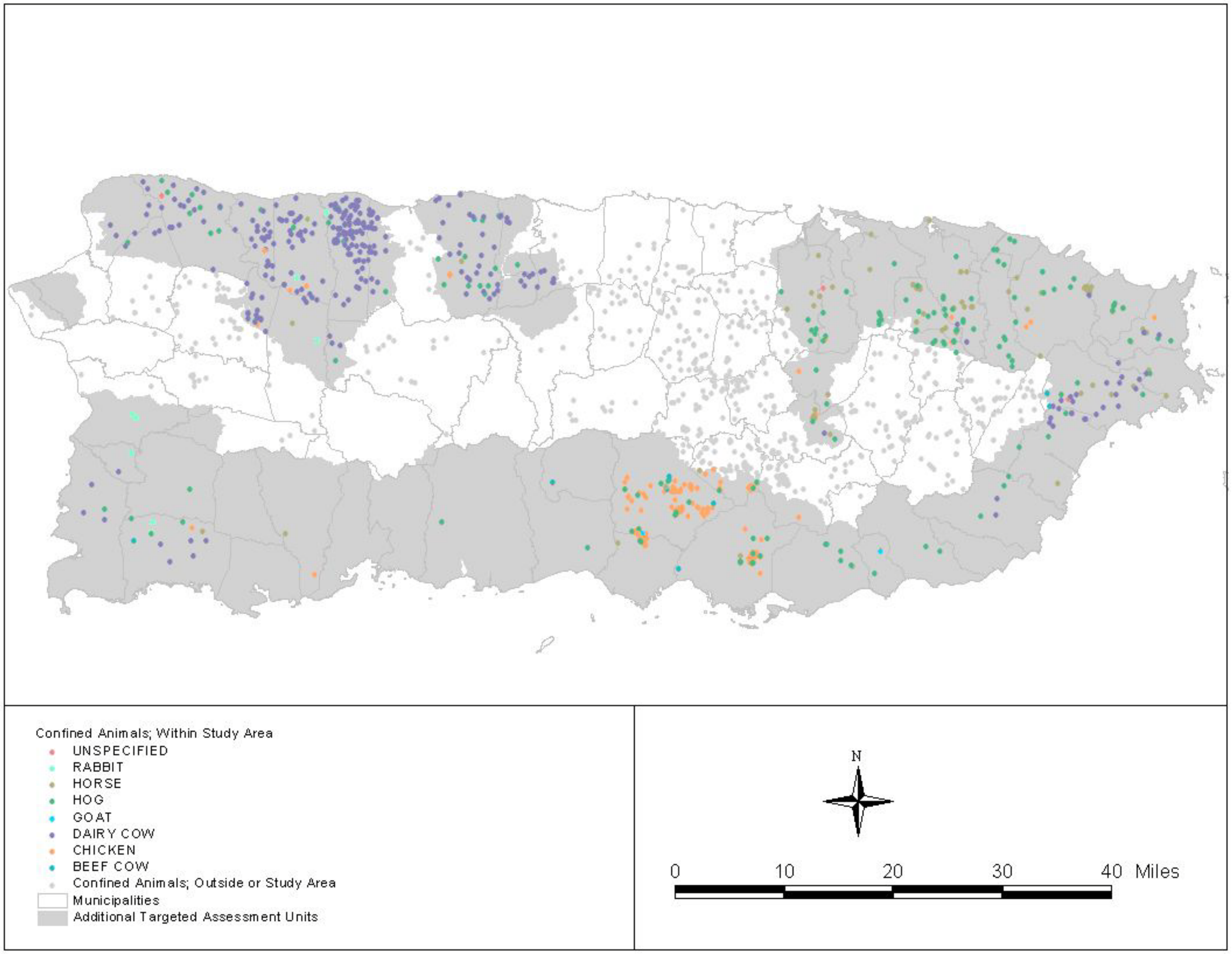

Figure 2-3. CAFO Locations in the study area.

Table 2-5. Urban landuse accumulation rates of fecal coliform bacteria

Landuse	FECALTOOL Loading Rate (count/ac/day)	Modeled Landuse	Average Loading Rate (count/ac/day)
Single family low density	1.03E+07		
		= Low / Medium Density	1.35E+07
Single family high density	1.66E+07		
		= Medium / High Density	2.00E+07
Multifamily residential	2.33E+07		

Table 2-6. Nonpermitted stormwater fecal coliform bacteria loads by Assessment Unit and landuse type.

Landuse Type	FC Units	Assessment Unit						
		PRNE7_1	UNC--1	PRSE69A	PRSL69A	PRSR69A1	PRWQ71A	UCW--1
Urban High Density	#/yr	3.60E+11	4.06E+09	1.31E+10	1.24E+09	9.67E+08	1.38E+09	3.17E+11
Urban Low Density	#/yr	3.29E+11	8.29E+11	1.04E+10	5.11E+10	4.13E+10	2.62E+09	1.68E+11
Landuse Type	FC Units	Assessment Unit						
		UCW--2	UCW--3	UVL-E	UVL-W	PRNE5A	PRNL3A1	PRNQ1A
Urban High Density	#/yr	2.37E+09	2.12E+10	1.44E+11	6.37E+10	1.32E+10	6.41E+09	2.79E+09
Urban Low Density	#/yr	2.47E+09	4.96E+09	2.20E+11	8.04E+10	3.30E+11	2.20E+11	2.95E+09
Landuse Type	FC Units	Assessment Unit						
		PRNQ3B	PRNR3A1	PRNR3A2	PRNR5A	UNC--2	UNC--3	PREE22A
Urban High Density	#/yr	4.92E+04	4.21E+05	4.21E+05	1.18E+09	9.78E+10	7.90E+09	1.51E+15
Urban Low Density	#/yr	3.53E+10	1.42E+10	2.20E+11	4.74E+11	1.30E+12	3.26E+11	5.65E+13
Landuse Type	FC Units	Assessment Unit						
		PREE29A	PREE31A	PREQ30B	PRER30A	UCW--4	UCW--5	UCW--6
Urban High Density	#/yr	2.39E+15	2.48E+15	1.20E+13	1.55E+15	1.54E+16	1.39E+16	5.12E+14
Urban Low Density	#/yr	2.36E+13	7.06E+12	4.44E+12	4.11E+13	6.35E+13	1.27E+13	4.05E+12
Landuse Type	FC Units	Assessment Unit						
		PRSE51A	PRSE53A	PRSR54A--1	PRSR54A--2	PRSR54A--3	PRSR54A--4	PRSR55A
Urban High Density	#/yr	1.07E+10	3.62E+10	1.67E+11	3.11E+10	0.00E+00	1.43E+10	8.22E+09
Urban Low Density	#/yr	6.23E+10	1.13E+11	1.58E+11	1.21E+11	2.65E+10	1.08E+11	9.81E+10
Landuse Type	FC Units	Assessment Unit						
		PRSR56A	PRSR57A1	PRSR57A2--1	PRSR57A2--2	PRSR57B	UCW--10	UCW--11
Urban High Density	#/yr	1.67E+10	1.37E+11	5.23E+10	2.98E+09	1.36E+09	3.28E+10	2.91E+10
Urban Low Density	#/yr	5.28E+10	5.85E+10	3.82E+11	1.37E+11	3.04E+11	2.99E+10	3.21E+10
Landuse Type	FC Units	Assessment Unit						
		UCW--12	UCW--7	UCW--8	UCW--9	PRELA2	PRER12A1	PRER12A2
Urban High Density	#/yr	3.53E+11	4.61E+11	1.61E+11	8.64E+09	0.00E+00	5.00E+11	1.03E+09
Urban Low Density	#/yr	3.17E+10	1.18E+11	6.44E+10	7.19E+09	1.06E+11	1.77E+11	5.81E+12
Landuse Type	FC Units	Assessment Unit						
		PRER12B	PRER12C	PRNR11A	PREQ14D	PREQ14E	PRER14A1	PRER14B
Urban High Density	#/yr	3.57E+11	9.60E+10	1.88E+12	8.22E+12	2.48E+10	2.56E+15	7.75E+14
Urban Low Density	#/yr	2.81E+11	2.16E+11	2.66E+11	1.22E+13	1.28E+13	7.64E+12	3.86E+13
Landuse Type	FC Units	Assessment Unit						
		PRER14C	URGL	PRSE48A	PRSL43A1	PRSR40A	PRSR42A	PRSR43A1
Urban High Density	#/yr	1.51E+14	1.71E+15	2.12E+14	0.00E+00	1.67E+14	3.48E+14	0.00E+00
Urban Low Density	#/yr	4.65E+12	1.04E+13	3.79E+11	7.44E+12	1.28E+13	9.92E+12	6.79E+10
Landuse Type	FC Units	Assessment Unit						
		PRSR43A2	PRSR43B	PRSR45A	PRSR47A	PRSR49A	UCW--13	UCW--14
Urban High Density	#/yr	0.00E+00	0.00E+00	1.52E+14	2.83E+13	1.07E+15	0.00E+00	8.37E+13
Urban Low Density	#/yr	3.87E+13	7.91E+12	1.16E+13	6.93E+12	1.63E+13	4.15E+10	4.39E+11
Landuse Type	FC Units	Assessment Unit						
		UCW--15	UCW--16	UCW--17	UCW--18	UCW--19	UCW--20	PRWR77A

Urban High Density	#/yr	3.05E+13	0.00E+00	9.83E+13	6.11E+13	0.00E+00	0.00E+00	6.27E+10
Urban Low Density	#/yr	8.43E+11	0.00E+00	5.88E+12	3.09E+11	3.21E+07	0.00E+00	1.48E+11
Landuse Type	FC Units	Assessment Unit						
		PRWR77B	PRWR77C	PRWR77D	PRWR77E	PRWR77F	PRWR77G	PRWR77H
Urban High Density	#/yr	1.69E+10	1.12E+10	6.04E+10	0.00E+00	7.88E+07	0.00E+00	7.01E+08
Urban Low Density	#/yr	7.91E+09	1.60E+11	8.15E+10	3.03E+11	9.28E+10	5.99E+10	8.35E+10
Landuse Type	FC Units	Assessment Unit						
		PRWR77I	UCW--21	UCW--22	UCW--23	UCW--24	PREE15A	PREE16A
Urban High Density	#/yr	1.60E+09	2.80E+10	1.71E+10	1.44E+11	1.47E+10	1.42E+14	6.47E+14
Urban Low Density	#/yr	1.02E+11	1.37E+10	1.03E+10	1.99E+10	2.02E+10	6.04E+11	3.54E+13
Landuse Type	FC Units	Assessment Unit						
		PREE17A	PREE19A	PREE20A	PREQ21A	PRER19A	UCW--25	UCW--26
Urban High Density	#/yr	7.69E+15	4.24E+14	1.75E+13	4.98E+13	1.35E+12	1.29E+16	0.00E+00
Urban Low Density	#/yr	4.22E+13	1.19E+13	6.52E+12	1.92E+11	2.00E+12	2.99E+13	7.09E+10
Landuse Type	FC Units	Assessment Unit						
		PRSE58A	PRSE60A	PRSE61A	PRSL160A	PRSL260A	PRSL62A1	PRSR59A--1
Urban High Density	#/yr	2.21E+10	1.13E+10	7.43E+09	1.50E+09	4.12E+10	1.48E+09	2.87E+08
Urban Low Density	#/yr	2.47E+11	6.99E+10	1.95E+11	1.20E+11	5.46E+11	1.21E+11	9.72E+10
Landuse Type	FC Units	Assessment Unit						
		PRSR59A--2	PRSR61A	PRSR62A1	PRSR63A--1	PRSR63A--2	PRSR64A--1	PRSR64A--2
Urban High Density	#/yr	1.81E+09	0.00E+00	2.44E+10	1.79E+10	5.75E+08	0.00E+00	7.72E+09
Urban Low Density	#/yr	3.06E+10	1.90E+11	2.00E+10	8.28E+10	2.61E+11	1.43E+10	1.46E+11
Landuse Type	FC Units	Assessment Unit						
		UCW--27	UCW--28	UCW--29	UCW--30	UCW--31	PREE33A	PREE34A
Urban High Density	#/yr	7.93E+10	9.50E+09	1.86E+10	1.34E+09	1.18E+11	9.94E+14	0.00E+00
Urban Low Density	#/yr	6.45E+09	2.72E+09	1.76E+09	2.13E+08	3.49E+10	1.45E+13	5.33E+11
Landuse Type	FC Units	Assessment Unit						
		PREE35A	PREK35.1	PRER37A	UCW--32	UCW--33	PRWR79A	UCW--34
Urban High Density	#/yr	1.69E+15	6.79E+15	2.72E+14	1.82E+15	1.01E+14	2.28E+10	4.32E+09
Urban Low Density	#/yr	4.46E+13	8.57E+12	1.02E+13	4.95E+12	9.07E+11	2.26E+10	1.38E+09
Landuse Type	FC Units	Assessment Unit						
		PRSL68A	PRSR65A--1	PRSR65A--2	PRSR66A	PRSR67A	PRSR68A	UCW--35
Urban High Density	#/yr	0.00E+00	1.19E+11	4.82E+08	1.61E+09	1.25E+10	3.76E+09	1.04E+11
Urban Low Density	#/yr	1.71E+11	1.94E+11	5.10E+10	2.34E+10	1.38E+11	1.00E+11	4.37E+10
Landuse Type	FC Units	Assessment Unit						
		UCW--36	UCW--37	UCW--38	UCW--39	PREE13A1	PREE13A2	PREE13A3
Urban High Density	#/yr	1.17E+10	5.57E+11	1.55E+09	4.63E+09	2.38E+15	2.28E+15	1.71E+16
Urban Low Density	#/yr	2.28E+10	7.23E+10	1.09E+09	1.82E+09	0.00E+00	1.92E+12	1.34E+13
Landuse Type	FC Units	Assessment Unit						
		UCW--40	PRWR94A	PRWK93A				
Urban High Density	#/yr	5.49E+14	0.00E+00	1.17E+10				
Urban Low Density	#/yr	9.49E+10	0.00E+00	0.00E+00				
Total Urban High Density Load (#/yr):			**1.01E+17**					
Total Urban Low Density Load (#/yr):			**6.65E+14**					

2.3.2.3 Wastewater Disposal

In addition to urban runoff contributions, other possible sources for contribution of fecal coliform bacteria from human waste to the system include the following:

- Illegal discharges of untreated wastewater
- Transport of water from failed septic systems toward a water body
- Leaking sewage mains

These processes are all more common in areas with higher populations, for example, in residential or commercial zones. Residential septic systems treat human waste using a collection system that discharges liquid waste into the soil through a series of distribution lines that comprise the drain field. Fecal coliform bacteria naturally die off as the effluent percolates through the soil to the groundwater. These systems effectively remove fecal coliform bacteria when properly installed and maintained. A septic system failure occurs when there is a discharge of waste to the soil surface where it is available for washoff into surface waters. Failing septic systems can deliver high bacteria loads to surface waters, depending on the proximity of the discharge to a waterbody and the timing of rainfall events. Septic system failures typically occur in older systems that are not adequately maintained with periodic sewage pump-outs.

Septic system failure may be a more significant source of fecal coliform bacteria, based on census data for the region. Based on 2000 Census data, the estimated population in the watershed is 2,478,423. Based on the percentage of households that are sewered, on septics, or other from the Census 1990 by municipality (see Appendix A, this breakdown was not available for Census 2000), it is estimated that approximately 32 percent (804,485) of the population in this watershed is serviced by on-site septic systems, and approximately 4 percent (103,504) are serviced by latrine systems. The service percentages vary by municipality based on Census data, and a spatial analysis was performed to area-weight the population for watersheds sharing more than one municipality. The remaining population is estimated to be sewered.

To calculate a fecal coliform bacteria load from failing septic systems, a 100 percent failure rate was used for latrines, and a 10 percent failure rate was used for septic systems (a rate used in the *Salt River Bay Biochemical Oxygen Demand TMDL* (USEPA 2004)). EPA's *Onsite Wastewater Treatment Systems Manual* (USEPA 2002) provides an estimate of average daily wastewater flows in residential systems of between 50 and 70 gallons per capita per day (GPCD) for residential dwellings built before 1994 and between 40 and 60 GPCD for residential dwellings built after 1994 (U.S. Energy Policy Act standards went into effect in 1994). Considering the nature of the housing stock of the unsewered areas in Puerto Rico, an estimate of 50 GPCD was selected to develop a population-based estimate. Horsley and Witten (1996) estimated that septic system discharge contains a concentration of 1e4 (10,000) colony forming units (CFU)/100 mL, while Metcalf and Eddy (1991) estimated typical concentrations in untreated sewage at 1e6 (1,000,000) CFU/100 mL. On the basis of these estimates, an average value of 1e5 (100,000) CFU/100 mL was selected for use in the TMDL. Table 2-7 presents estimated septic system loading rates by modeled subwatershed. A map of the modeled subwatersheds is shown in Figure 4-1.

Table 2-7. Fecal coliform bacteria loading rates from failing septic systems by subwatershed

Assessment Unit	Population	Sewered Population	Population on Septic	Population on "other"	Population on failing system (other + 10% on septic)	Flow Overcharge (gal/person/ day)	Total Flow (cfs)	Fecal Coliform Conc (#/100mL)	FC Load (#/yr)
PREE13A1	53775	46751	6544	480	1134	50	0.0878	100000	7.85E+13
PREE13A2	215087	200707	12527	1854	3106	50	0.2403	100000	2.15E+14
PREE13A3	260046	231958	25443	2645	5189	50	0.4015	100000	3.59E+14
PREE15A	6784	3354	3155	276	591	50	0.0458	100000	4.10E+13
PREE16A	21170	11330	9084	757	1665	50	0.1288	100000	1.15E+14
PREE17A	12923	7390	5140	393	907	50	0.0702	100000	6.28E+13
PREE19A	5556	3673	1786	97	276	50	0.0214	100000	1.91E+13
PREE20A	2223	1470	713	39	110	50	0.0085	100000	7.65E+12
PREE22A	28681	21186	6814	681	1362	50	0.1054	100000	9.44E+13
PREE29A	3140	1185	1789	166	345	50	0.0267	100000	2.39E+13
PREE31A	10526	6194	3843	488	873	50	0.0675	100000	6.05E+13
PREE33A	30544	16460	12604	1479	2739	50	0.2119	100000	1.90E+14
PREE34A	8806	5223	3175	408	726	50	0.0561	100000	5.03E+13
PREE35A	27869	11405	14393	2070	3510	50	0.2715	100000	2.43E+14
PREK35.1	6971	2852	3601	518	878	50	0.0680	100000	2.43E+14
PRELA2	9755	2937	6266	552	1179	50	0.0912	100000	8.15E+13
PREQ14D	37677	32444	4892	341	830	50	0.0642	100000	5.75E+13
PREQ14E	36473	22537	12807	1129	2409	50	0.1864	100000	1.67E+14
PREQ21A	10533	7958	2354	221	456	50	0.0353	100000	3.16E+13
PREQ30B	2245	850	1276	119	246	50	0.0191	100000	1.71E+13
PRER12A1	76740	63158	12981	600	1898	50	0.1468	100000	1.31E+14
PRER12A2	31209	13564	16327	1317	2950	50	0.2282	100000	2.04E+14
PRER12B	90248	71231	18053	964	2769	50	0.2142	100000	1.91E+14
PRER12C	24982	21732	3090	160	469	50	0.0363	100000	3.24E+13
PRER14A1	62360	48653	12615	1091	2353	50	0.1820	100000	1.46E+14
PRER14B	22314	9349	11842	1123	2307	50	0.1785	100000	1.60E+14
PRER14C	46875	37011	9112	752	1663	50	0.1286	100000	1.15E+14
PRER19A	4921	3252	1583	86	245	50	0.0189	100000	1.69E+13
PRER30A	10221	3858	5823	541	1123	50	0.0869	100000	7.78E+13
PRER37A	11195	3851	5310	2034	2565	50	0.1984	100000	1.78E+14
PRNE5A	12270	3054	8485	731	1580	50	0.1222	100000	1.09E+14
PRNE7.1	33183	15879	15998	1306	2906	50	0.2248	100000	1.09E+14
PRNL3A1	6389	1805	4232	352	775	50	0.0600	100000	5.36E+13
PRNQ1A	10580	4923	5241	416	940	50	0.0727	100000	6.50E+13
PRNQ3B	3063	921	2018	124	326	50	0.0252	100000	2.25E+13
PRNR11A	81882	69557	11643	682	1846	50	0.1428	100000	1.28E+14
PRNR3A1	6431	1501	4679	251	719	50	0.0556	100000	4.97E+13
PRNR3A2	8349	2654	5089	606	1115	50	0.0863	100000	7.71E+13
PRNR5A	5784	1789	3474	521	868	50	0.0672	100000	6.00E+13
PRSE48A	1841	1235	458	148	194	50	0.0150	100000	1.35E+13
PRSE51A	7657	5136	1905	616	807	50	0.0624	100000	5.60E+13
PRSE53A	4201	1884	1740	577	751	50	0.0581	100000	5.22E+13
PRSE58A	12352	4549	6886	917	1605	50	0.1242	100000	1.12E+14
PRSE60A	13948	4724	8000	1223	2023	50	0.1565	100000	1.41E+14
PRSE61A	39576	29919	8151	1505	2320	50	0.1795	100000	1.61E+14
PRSE69A	2862	1243	1357	262	398	50	0.0308	100000	2.77E+13
PRSL160A	15914	3616	10582	1716	2774	50	0.2146	100000	1.93E+14

Assessment Unit	Population	Sewered Population	Population on Septic	Population on "other"	Population on failing system (other + 10% on septic)	Flow Overcharge (gal/person/ day)	Total Flow (cfs)	Fecal Coliform Conc (#/100mL)	FC Load (#/yr)
PRSL260A	14749	3924	9420	1404	2346	50	0.1815	100000	1.63E+14
PRSL43A1	1235	367	732	135	209	50	0.0161	100000	1.45E+13
PRSL62A1	27581	21199	5374	1008	1545	50	0.1195	100000	1.08E+14
PRSL68A	11732	5291	4969	1472	1969	50	0.1524	100000	1.37E+14
PRSL69A	5698	2570	2415	714	955	50	0.0739	100000	6.65E+13
PRSR40A	2240	667	1327	246	379	50	0.0293	100000	2.63E+13
PRSR42A	3083	917	1828	338	521	50	0.0403	100000	3.62E+13
PRSR43A1	1472	468	848	157	242	50	0.0187	100000	1.68E+13
PRSR43A2	7871	2351	4658	862	1328	50	0.1027	100000	9.22E+13
PRSR43B	1906	568	1129	209	322	50	0.0249	100000	2.24E+13
PRSR45A	10452	5474	4195	783	1202	50	0.0930	100000	8.35E+13
PRSR47A	3108	2083	775	250	328	50	0.0253	100000	2.27E+13
PRSR49A	8726	5850	2174	702	920	50	0.0711	100000	6.39E+13
PRSR54A--1	7541	3254	3219	1068	1390	50	0.1075	100000	9.66E+13
PRSR54A--2	7183	3576	2751	856	1131	50	0.0875	100000	7.86E+13
PRSR54A--3	8609	5020	3202	388	708	50	0.0548	100000	4.92E+13
PRSR54A--4	7319	3665	2977	677	975	50	0.0754	100000	6.77E+13
PRSR55A	4140	1790	1996	354	553	50	0.0428	100000	3.85E+13
PRSR56A	3335	1759	1338	237	371	50	0.0287	100000	2.58E+13
PRSR57A1	4267	2252	1712	303	475	50	0.0367	100000	3.30E+13
PRSR57A2--1	14227	6038	7411	778	1519	50	0.1175	100000	1.06E+14
PRSR57A2--2	2826	1148	1532	146	299	50	0.0232	100000	2.08E+13
PRSR57B	18188	8055	9182	952	1870	50	0.1447	100000	1.30E+14
PRSR59A--1	13548	10421	2633	494	757	50	0.0586	100000	5.27E+13
PRSR59A--2	5354	1772	3110	473	784	50	0.0606	100000	5.45E+13
PRSR61A	10570	3517	6121	932	1544	50	0.1194	100000	1.07E+14
PRSR62A1	17813	13704	3460	649	995	50	0.0770	100000	6.92E+13
PRSR63A--1	15661	12048	3042	571	875	50	0.0677	100000	6.09E+13
PRSR63A--2	13806	10332	2926	548	841	50	0.0650	100000	5.85E+13
PRSR64A--1	9175	6701	2068	406	613	50	0.0474	100000	4.26E+13
PRSR64A--2	16875	12981	3279	615	943	50	0.0730	100000	6.56E+13
PRSR65A--1	14573	3490	9011	2072	2973	50	0.2300	100000	2.07E+14
PRSR65A--2	4783	1129	2971	684	981	50	0.0759	100000	6.83E+13
PRSR66A	5205	1579	2887	738	1027	50	0.0795	100000	7.15E+13
PRSR67A	14073	5219	6901	1953	2643	50	0.2045	100000	1.84E+14
PRSR68A	19192	8611	8188	2393	3212	50	0.2485	100000	2.24E+14
PRSR69A1	7465	3293	3426	746	1089	50	0.0842	100000	7.59E+13
PRWQ71A	3202	1147	1830	225	408	50	0.0316	100000	2.85E+13
PRWR77A	28429	12959	13950	1519	2914	50	0.2255	100000	2.03E+14
PRWR77B	8417	5545	2619	252	514	50	0.0398	100000	3.59E+13
PRWR77C	18626	10484	7021	1121	1823	50	0.1411	100000	1.27E+14
PRWR77D	15508	6068	8240	1200	2024	50	0.1566	100000	1.41E+14
PRWR77E	9474	4129	4541	804	1258	50	0.0973	100000	8.78E+13
PRWR77F	5539	2407	2655	477	743	50	0.0575	100000	5.19E+13
PRWR77G	2898	1260	1389	249	388	50	0.0300	100000	2.71E+13
PRWR77H	5427	2334	2765	328	605	50	0.0468	100000	4.22E+13
PRWR77I	7081	3043	3622	416	778	50	0.0602	100000	5.43E+13
PRWR79A	24261	16491	7034	736	1439	50	0.1113	100000	1.01E+14
UCW--1	23774	8265	13376	2132	3470	50	0.2684	100000	2.42E+14
UCW--10	2985	1927	799	260	339	50	0.0263	100000	2.36E+13

Assessment Unit	Population	Sewered Population	Population on Septic	Population on "other"	Population on failing system (other + 10% on septic)	Flow Overcharge (gal/person/ day)	Total Flow (cfs)	Fecal Coliform Conc (#/100mL)	FC Load (#/yr)
UCW--11	1767	762	754	250	326	50	0.0252	100000	2.26E+13
UCW--12	7402	3905	2970	526	823	50	0.0637	100000	5.72E+13
UCW--13	1589	884	584	121	179	50	0.0139	100000	1.25E+13
UCW--14	7409	3846	3003	560	860	50	0.0665	100000	5.97E+13
UCW--15	888	264	527	97	150	50	0.0116	100000	1.04E+13
UCW--16	33	10	20	4	6	50	0.0004	100000	3.90E+11
UCW--17	1339	400	790	149	228	50	0.0177	100000	1.58E+13
UCW--18	2375	1593	591	191	250	50	0.0194	100000	1.74E+13
UCW--19	276	185	69	22	29	50	0.0023	100000	2.02E+12
UCW--2	2057	737	1175	145	262	50	0.0203	100000	1.83E+13
UCW--20	134	40	79	15	23	50	0.0018	100000	1.57E+12
UCW--21	1560	559	891	110	199	50	0.0154	100000	1.39E+13
UCW--22	554	199	317	39	71	50	0.0055	100000	4.93E+12
UCW--23	14462	9831	4193	439	858	50	0.0664	100000	5.99E+13
UCW--24	7290	2611	4166	512	929	50	0.0719	100000	6.48E+13
UCW--25	33304	17361	14743	1201	2675	50	0.2069	100000	1.85E+14
UCW--26	221	146	71	4	11	50	0.0008	100000	7.60E+11
UCW--27	2423	1278	972	172	270	50	0.0208	100000	1.87E+13
UCW--28	8741	6725	1698	319	488	50	0.0378	100000	3.40E+13
UCW--29	12094	9304	2349	441	676	50	0.0523	100000	4.70E+13
UCW--3	5498	2327	2561	610	866	50	0.0670	100000	6.03E+13
UCW--30	4425	3190	1048	187	291	50	0.0225	100000	2.03E+13
UCW--31	13444	4449	7808	1187	1968	50	0.1523	100000	1.37E+14
UCW--32	4206	1624	2109	473	684	50	0.0529	100000	4.75E+13
UCW--33	3384	1698	1482	204	352	50	0.0272	100000	2.44E+13
UCW--34	4639	3153	1345	141	275	50	0.0213	100000	1.92E+13
UCW--35	11161	7134	3330	697	1030	50	0.0796	100000	7.16E+13
UCW--36	2533	906	1270	357	484	50	0.0375	100000	3.37E+13
UCW--37	2334	709	1294	331	460	50	0.0356	100000	3.21E+13
UCW--38	917	328	460	129	175	50	0.0136	100000	1.22E+13
UCW--39	1850	661	928	261	354	50	0.0274	100000	2.46E+13
UCW--4	12542	6463	5519	561	1113	50	0.0861	100000	7.71E+13
UCW--40	8939	8454	411	74	115	50	0.0089	100000	7.97E+12
UCW--5	12230	8656	3223	351	673	50	0.0521	100000	4.67E+13
UCW--6	16720	9710	6231	779	1402	50	0.1085	100000	9.72E+13
UCW--7	7239	3124	3090	1025	1334	50	0.1032	100000	9.27E+13
UCW--8	7531	5052	1873	606	793	50	0.0614	100000	5.51E+13
UCW--9	367	193	147	26	41	50	0.0032	100000	2.83E+12
UNC--1	59017	29036	26986	2994	5693	50	0.4404	100000	3.94E+14
UNC--2	109005	30734	72206	6065	13286	50	1.0278	100000	9.18E+14
UNC--3	90824	35802	51042	3980	9084	50	0.7028	100000	6.28E+14
URGL	9984	4343	5169	472	989	50	0.0765	100000	6.84E+13
UVL-E	30469	10365	17009	3096	4797	50	0.3711	100000	3.34E+14
UVL-W	13913	4629	8073	1211	2018	50	0.1561	100000	1.41E+14
PRWR94A	17220	4672	11257	1291	2417	50	0.1870	100000	1.67E+14
PRWK93A	7479	1981	5063	434	941	50	0.0728	100000	6.50E+13

2.3.2.4 Background Conditions

Background fecal coliform bacteria loads are from non-human, natural sources. Their contributions can be directly to a waterbody or to the watershed surface where they are ultimately carried to a waterbody. Watershed contributions can be estimated from water quality data collected at headwater stations where the contributing land consists almost entirely of natural landscape with little or no human influence. Native bird and mammal populations residing in and around the streams can contribute fecal coliform bacteria directly to the river system. Similarly, flocks of native or migrating birds can land for a short time, and contribute to the bacteria load before departing.

The fecal coliform accumulation rate for background conditions was calculated using an estimate of 10 small animals per square mile. A rate of 8.02E9 count/animal/day was used (8,020,000,000 count/animal/day). This value is the average loading rate for small animals from EPA's Bacteria Indicator Tool. An estimated 50 percent of the accumulated load was assumed to be available for runoff to carry into the streams. Using these inputs, the estimated accumulation rate of fecal coliform bacteria for forested areas was 6.26E7 count/acre/day (62,600,000 count/animal/day).

2.4 Current Conditions

The TMDLs were developed on the basis of conditions that existed from 1995 to 2004. This time frame is concurrent with the majority of the available ambient water quality and flow data. Although data were collected over a significant time frame and at regular intervals, they do not demonstrate insight to suggest improvement or deterioration over this time period. However, seasonal trends are observed. Section 3 summarizes the available data.

3 DATA ANALYSIS

3.1 Monitoring Data

The study area has elevated fecal coliform bacteria concentrations. Data from stations in the watersheds were reviewed to obtain an initial estimate of critical conditions. Water quality stations that also measure flow are most useful for this initial analysis, because flow also provides insight into meteorological conditions and thus the sources affecting the waterbody.

Records for 142 USGS gages were obtained for the study area. Of the 142, 69 collected flow data within the time frame represented by the modeling effort, and 18 gages provide coincident fecal coliform measurements within the time period of interest. The coincident datasets are listed in Table 3-1, and the locations of the stations are shown in Figure 3-1.

Table 3-1. USGS gages with coincident flow and fecal coliform data.

Site Number	Station Name	8-digit HUC	Assessment Unit	Reported Drainage Area (mi^2)	Altitude (feet)
50010500	RIO GUAJATACA AT LARES, PR	21010004	PRNR3A2	3.16	944.9
50011000	CANAL DIVERSION LAGO GUAJATACA, PR	21010002	PRNR3A1		689
50011400	RIO GUAJATACA ABV MOUTH NR QUEBRADILLAS, PR	21010002	PRNR3A1		
50048770	RIO PIEDRAS AT EL SENORIAL, PR	21010005	PREE13A2	7.49	196.9
50049100	RIO PIEDRAS AT HATO REY, PR	21010005	PREE13A2	15.2	3.2
50059050	RIO GRANDE DE LOIZA BLW LOIZA DAMSITE, PR	21010005	PRER14A1	209	49.2
50063800	RIO ESPIRITU SANTO NR RIO GRANDE, PR	21010005	PREE16A	8.62	40
50071000	RIO FAJARDO NR FAJARDO, PR	21010005	PREE22A	14.9	137.6
50082000	RIO HUMACAO AT HWY 3 AT HUMACAO, PR	21010005	PREE33A	17.3	49.2
50083500	RIO GUAYANES NR YABUCOA, PR	21010005	PREE35A	17.2	147.6
50092000	RIO GRANDE DE PATILLAS NR PATILLAS, PR	21010004	PRSR43A2	18.3	235
50110900	RIO TOA VACA ABV LAGO TOA VACA, PR	21010004	PRSL260A	14.2	557.74
50114000	RIO CERRILLOS BLW LAGO CERRILLOS NR PONCE, PR	21010004	PRSR62A1	17.8	360.9
50115000	RIO PORTUGUES NR PONCE, PR	21010004	PRSR63A	8.82	470
50115900	RIO PORTUGUES AT HWY 14 AT PONCE, PR	21010004	PRSR63A	18.6	49.2
50136000	RIO ROSARIO AT ROSARIO, PR	21010003	PRWR77C	16.4	230
50136400	RIO ROSARIO NR HORMIGUEROS, PR	21010003	PRWR77C	18.3	164.04
50138000	RIO GUANAJIBO NR HORMIGUEROS, PR	21010003	PRWR77A	120	7.36

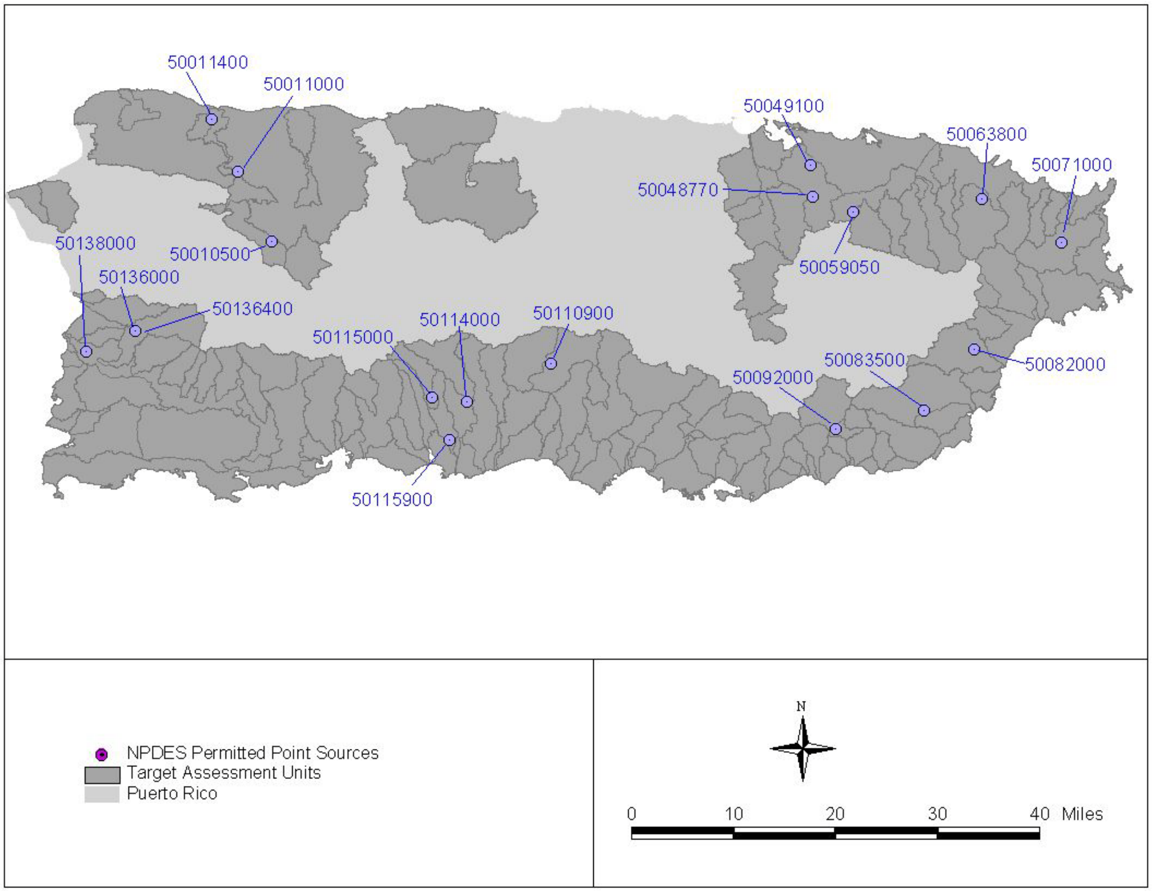

Figure 3-1. Flow and water quality stations in the watershed system.

USGS water quality station 50071000, Río Fajardo near Fajardo, provides bacteria data (n = 165) collected between 1980 and 2010. Although the stations in Table 3-1 could be subjected to the same analysis, this station provides the highest quantity of coincident USGS data points in the study area for flow and fecal coliform, so this station was used to further investigate flow (and thus seasonal) conditions in the system. Table 3-2 presents the data in tabular format and categorizes the data by flow percentile. The same data are graphically presented in Figure 3-2.

The data shown in Table 3-2 and Figure 3-2 suggest that the majority of bacteria loading occur during higher flow conditions in the watershed. Although Table 3-2 and Figure 3-2 clearly suggest that moderate flows (40–50th percentile) and higher flows (70–100th percentile) exhibit higher fecal coliform bacteria concentrations, all flow percentiles above the 30th percentile exhibit average bacteria concentrations higher than the geomean criteria concentration of 200 colonies/100 mL. Therefore, both point and nonpoint source loading of bacteria are likely significant sources of bacteria in this watershed. The Source Assessment section discusses potential point source and nonpoint source contributions in the watershed.

Table 3-2. Fecal coliform bacteria data grouped by flow percentile at 50071000 (Río Fajardo near Fajardo).

Location: 50071000: RIO FAJARDO NR FAJARDO, PR
Flow Gage: USGS50071000 (cfs)
Pollutant: Fecal Coliform (#/100 mL)
Data from: 1/8/1980 to 3/22/2010 (165 Observations)

Flow Range	# Obs	Associated Flow (cfs)			Pollutant Concentration (#/100mL)		
Percentile	Count	Mean	Min	Max	Mean	Min	Max
0-10	17	6.9	2.7	9.2	183	10	690
10-20	16	12.2	10.0	14.0	183	10	910
20-30	17	17.1	15.0	19.0	153	20	480
30-40	16	20.8	19.0	23.0	439	40	3200
40-50	16	25.1	23.0	27.0	3313	30	53000
50-60	17	32.6	28.0	37.0	348	27	900
60-70	16	41.8	37.0	49.0	720	40	3400
70-80	17	60.1	49.0	70.0	7802	45	58000
80-90	16	102.1	76.0	138.0	7059	50	49000
90-100	16	353.8	158.0	903.0	5352	270	60000

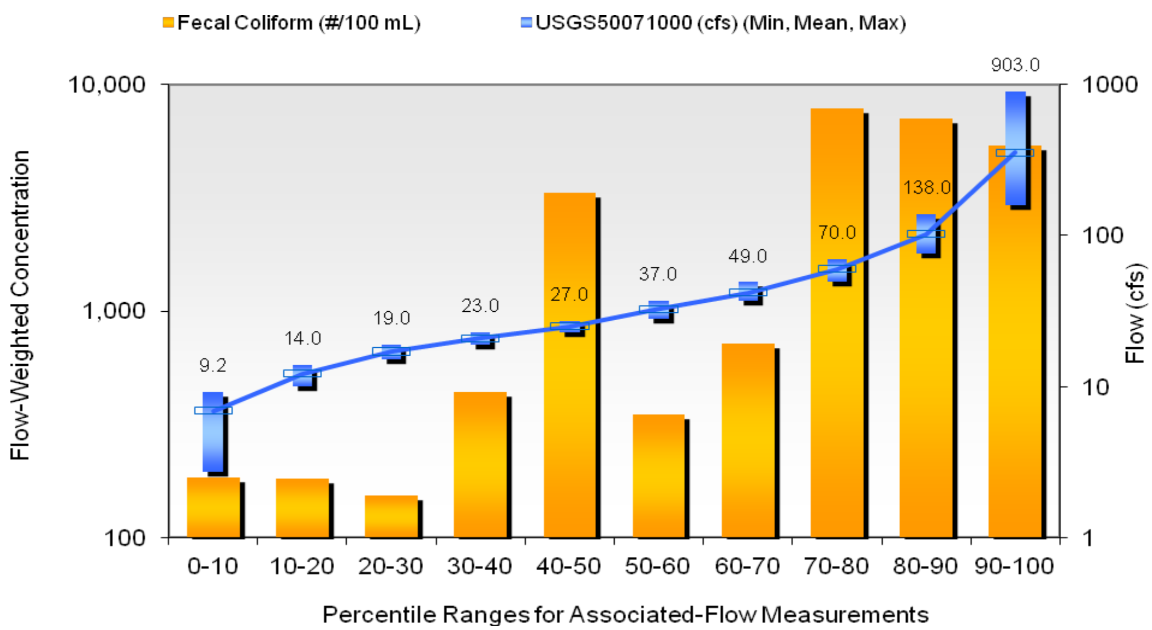

Figure 3-2. Bacteria data grouped by flow percentile at 50071000 (Río Fajardo near Fajardo).

Table 3-3. Fecal coliform bacteria data grouped by month at 50071000 (Río Fajardo near Fajardo).

Location: 50071000: RIO FAJARDO NR FAJARDO, PR
Flow Gage: USGS50071000 (cfs)
Pollutant: Fecal Coliform (#/100 mL)
Data from: 1/8/1980 to 3/22/2010 (165 Observations)

Time Period	# Obs	Associated Flow (cfs)			Pollutant Concentration (#/100mL)		
Month	Count	Mean	Min	Max	Mean	Min	Max
January	9	36.1	11.0	61.0	11104	20	58000
February	21	37.7	7.1	185.0	576	10	2000
March	11	207.4	8.2	1310.0	31622	10	53000
April	15	34.0	3.1	112.0	1126	10	5000
May	12	149.1	8.7	903.0	2292	20	12000
June	19	52.5	4.3	389.0	6102	30	49000
July	7	42.1	15.0	76.0	8702	44	36000
August	23	74.2	2.7	493.0	3300	27	19000
September	8	44.8	11.0	169.0	1058	130	1500
October	15	77.9	9.1	428.0	7754	110	53000
November	13	83.7	17.0	533.0	459	20	2400
December	12	72.9	20.0	228.0	18707	40	60000

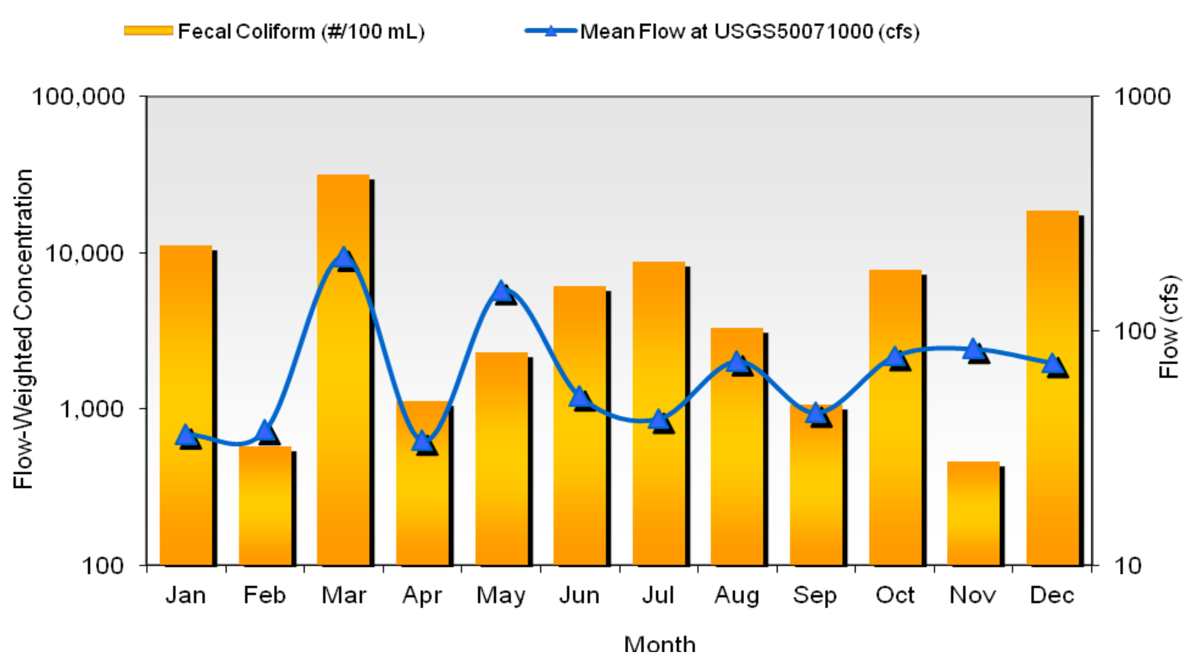

Figure 3-3. Bacteria data grouped by month at USGS 50071000 (Río Fajardo near Fajardo).

3.2 Critical Conditions

The goal of the TMDL is to determine the assimilative capacity of a waterbody on the basis of established water quality standards and to identify potential allocation scenarios that enable the waterbody to achieve the standards. The critical condition is the set of environmental conditions for which controls designed to protect water quality will ensure attainment of objectives for all other conditions. This is typically the period of time in which the impaired waterbody exhibits the most vulnerability.

Puerto Rico experiences relatively high humidity in the summer, and most rainfall occurs between May and December. Rain, which can be locally heavy, can be expected any time of the year. Most rain have a short duration. The hurricane season runs from June to November, but hurricanes occur most often between August and October.

Flow data from the watershed were used to identify whether elevated bacteria levels occur during rainfall events (and are likely watershed-driven) or during dry conditions.
Available data for the watershed were evaluated with respect to seasonality to identify possible trends and critical conditions. As shown in Section 3.1, the data suggest that low-flow conditions and high-flow periods are the critical periods in the watershed.

The TMDL analytical framework (further described in subsequent sections) predicts bacteria concentrations in-stream and in tidally influenced portions of the system on the basis of all sources present. Note that the TMDL analytical approach considers all conditions for TMDL development, not only the critical condition. It also considers dry condition sources (e.g., septic system failure) in addition to rainfall-driven sources.

4 ANALYTICAL APPROACH

Establishing the relationship between the in-stream water quality targets and source loadings is a critical component of TMDL development. It allows for evaluation of management options that will achieve the desired source load reductions necessary to meet water quality standards. The link can be established through a range of techniques, from qualitative assumptions based on sound scientific principles to sophisticated modeling techniques. Ideally, the linkage will be supported by monitoring data that allow the TMDL developer to associate certain waterbody responses with flow and loading conditions. This section presents the approach taken to develop the linkage between sources and in-stream response for TMDL development.

A watershed model is a useful tool for providing a quantitative linkage between sources and in-stream response. It is essentially a series of algorithms applied to watershed characteristics and meteorological data to simulate naturally occurring, land-based processes over an extended period, including hydrology and pollutant transport. Many watershed models are also capable of simulating in-stream processes using the land-based and subsurface calculations as input. After a model has been adequately set up and calibrated for a watershed, it can be used to quantify the existing loading of pollutants from subwatersheds or from land use categories and also can be used to assess the effects of a variety of management scenarios.

To support TMDL development objectives and evaluate the linkage between bacteria sources and in-stream water quality, Tetra Tech created an analytical framework using a detailed watershed loading model. The LSPC model was used to simulate source loading and attenuation of bacteria in the watershed. The following technical factors were fundamental to selecting an appropriate watershed model to support development of the TMDLs:

- The model is able to address a variety of pollutants including the pollutants of concern (e.g., bacteria).
- The model is able to simulate processes and interactions in the surface and subsurface environments.
- The model is able to address a watershed with mixed land uses.
- The model can provide adequate time-step estimation of flow and not oversimplify storm events to provide accurate representation of rainfall events and resulting peak runoff.
- The model is capable of simulating various pollutant transport mechanisms (e.g., groundwater contributions, sheet flow).

The LSPC (USEPA 2003a) was selected for simulation of watershed hydrology and water quality. The present version of LSPC includes algorithms for simulating pollutant accumulation and washoff of land surfaces and is a component of EPA's TMDL Modeling Toolbox (Toolbox) (USEPA 2003b), which has been developed through a joint effort between EPA and Tetra Tech. LSPC integrates comprehensive data storage and management capabilities and a dynamic watershed model (a re-coded version of EPA's Hydrological Simulation Program – FORTRAN [HSPF] [Bicknell et al. 1996]) that dictates no software requirements.

Because LSPC is based on a re-coded version of HSPF, a brief overview of HSPF is provided here. HSPF is a comprehensive watershed and receiving water quality modeling framework that was originally developed in the mid-1970s. During the past several years, it has been used to develop hundreds of EPA-approved TMDLs, and it is generally considered the most advanced hydrologic and watershed loading model available. The hydrologic portion of HSPF is based on the Stanford Watershed Model (Crawford and Linsley 1966), which was one of the pioneering watershed models developed in the 1960s. The HSPF framework is developed modularly with many different components that can be assembled in different ways, depending on the objectives of a project. The model includes three major modules:

- PERLND for simulating watershed processes on pervious land areas
- IMPLND for simulating processes on impervious land areas
- RCHRES for simulating processes in streams and vertically mixed lakes

All three of these modules include many subroutines that calculate the various hydrologic and water quality processes in the watershed. Many options are available for both simplified and complex process formulations. Spatially, the watershed is divided into a series of subwatersheds representing the drainage areas that contribute to each of the stream reaches. These subwatersheds are then further subdivided into segments representing different land uses. For the developed areas, the land use segments are further divided into the pervious (PERLND) and impervious (IMPLND) fractions. The stream network (RCHRES) links the surface runoff and groundwater flow contributions from each of the land segments and subbasins and routes them through the waterbodies using storage routing techniques. The stream model includes precipitation and evaporation from the water surfaces as well as flow contributions from the watershed, tributaries, and upstream stream reaches. It also accommodates flow withdrawals. The stream network is constructed to represent all the major tributary streams and different portions of stream reaches where significant changes in water quality occur.

4.1 Watershed Model Configuration

The LSPC model was configured for the areas contributing to impaired streams in the system and then used to simulate a series of hydrologically connected subwatersheds. Configuring the model involved subdividing the watersheds into modeling units, followed by continuous simulation of flow and water quality for these units using meteorological, land use, soils, stream, and bacteria data. Development and application of the watershed model to address the project objectives involved the following major steps, which are discussed further below:

1. Watershed delineation
2. Configuration of key watershed model components
3. Watershed model calibration and validation

4.1.1 Watershed Delineation

Watershed delineation refers to subdividing the entire watershed into smaller, discrete subwatersheds for modeling and analysis. LSPC calculates watershed processes on the basis of user defined, hydrologically connected subwatersheds. This subdivision was primarily based on stream networks and topographic variability and secondarily on the locations of flow and water quality monitoring stations to facilitate model calibration. PREQB’s assessment units were used as a template to delineate watersheds at a higher resolution for modeling purposes. Over 1,000 subwatersheds (1,122) were defined for the study area, as shown in Figure 4-1.

4.1.2 Configuration of Key Watershed Model Components

Configuring the watershed model involved considering the following major components:

- Waterbody representation
- Land use representation
- Meteorological data
- Hydrologic representation
- Pollutant representation

These components provided the basis for the LSPC model’s ability to estimate flow and pollutant loadings. Detailed discussions about developing each component for the LSPC model are provided in the following subsections.

4.1.2.1 Waterbody Representation

Waterbody representation refers to modules or algorithms in the LSPC model used to simulate flow and pollutant transport through streams, rivers, and lakes. Each delineated subwatershed was represented with a single stream or lake feature. EPA's National Hydrography Dataset (NHD) stream reach network (circa 2010) was used to determine the representative stream length for each subwatershed. The stream lengths were used with the 30-meter National Elevation Dataset to calculate reach slope. One of the watersheds was represented in the modeling as being drained by a lake feature (Lago de Cidra).

Assuming representative trapezoidal geometry for all streams, mean stream depth and channel width were estimated using regression curves that relate upstream drainage area to stream dimensions (Rosgen and Silvey 1996). Rating curves consisted of a representative depth-outflow-volume-surface area relationship. An estimated Manning's roughness coefficient of 0.02 was applied to each representative stream reach on the basis of typical literature values for natural streams (Chapra 1997).

Dimensions for Lago de Cidra were obtained from the USGS summary of lake characteristics (http://vi.water.usgs.gov/public/rt/pr_lakes/lake_50047550.html) and translated into the LSPC modeling environment. Based on this information, a rating curve was used to develop the capacity portion of a flow-volume relationship. Flow was takes place over a rectangular weir with dimensions estimated from photography provided by the website. The incremental surface area of the reservoir was estimated by calculating a three-dimentionsal trapezoid that approximated the volume-depth relationship provided by USGS.

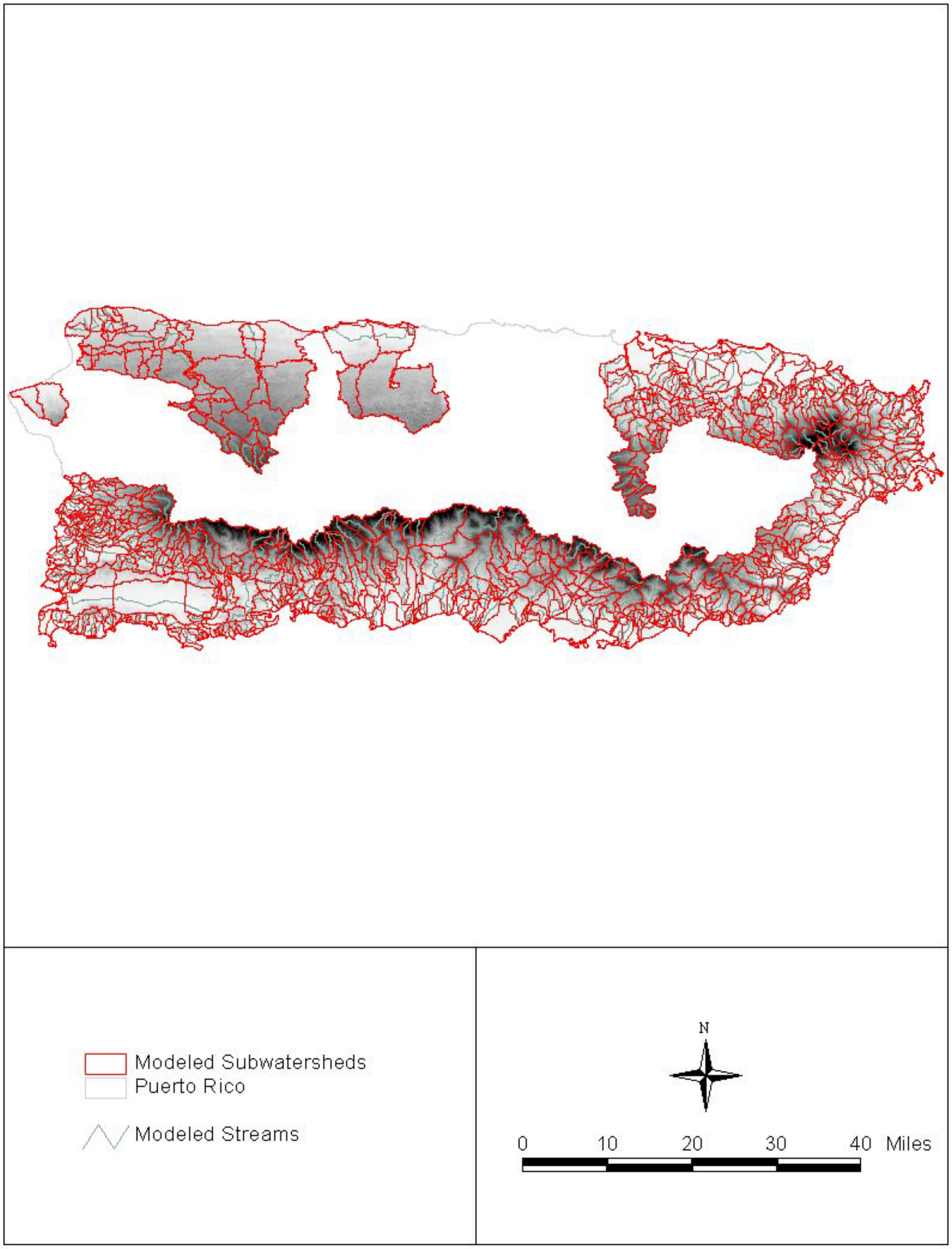

Figure 4-1. Modeled subwatersheds and simulated stream network.

All subwatersheds were conceptualized as part of a network of subbasin-stream pairs, where each subwatershed contributes a load to its representative stream, and also accepts a load from upstream reach segments. Streams are assumed to be completely mixed, one-dimensional segments with a constant trapezoidal cross-section. Smaller waterbody features like inland lagoons and small reservoirs, which may be listed as impaired, were represented in the model as water (as a land use type and not explicitly contributing to the load), but were not "simulated" as an explicit feature. However, because water landuses were not the bacteria load

4.1.2.2 Land Use Representation

The LSPC watershed model requires a basis for distributing hydrologic and pollutant loading parameters. Hydrologic variability within a watershed is influenced by land surface and subsurface characteristics. Variability in pollutant loading is highly correlated to land use practices. Land use representation provides the basis for distributing soils and pollutant loading characteristics throughout the watershed. Land cover data were obtained from the IITF and used as the basis for estimating pollutant loading from nonpoint sources. These data provide land cover data as of 2000, which fall within the model calibration and validation periods (1995–2004) discussed later in this section. Land use area within each subbasin is provided in Appendix D: Subbasin Land Use Area.

LSPC algorithms require that land use categories be divided into separate pervious and impervious land units for modeling. This division was made for the appropriate land uses (primarily urban) to represent impervious and pervious areas separately. The division was based on typical impervious percentages associated with different land use types from the Soil Conservation Service's TR-55 Manual (USDA 1986) as summarized in Table 4-1. Land use distribution in the study area is shown in Figure 4-2.

Table 4-1. Land cover data and for the study area and aggregation into simulated land use categories

ID	Land Cover Description	Modeled Landuse	Area (ac)	%
0	Background/water	Water	8,921	0.70%
1	High-Medium Density Urban	Urban_HighD	63,420	4.96%
2	Low-Medium Density Urban	Urban_LowD	130,787	10.23%
3	Herbaceous Agriculture - Cultivated Lands	Agriculture	22,482	1.76%
4	Active Sun Coffee and Mixed Woody Agriculture	Agriculture	9,539	0.75%
5	Pasture, Hay or Inactive Agriculture (e.g. abandoned sugar cane)	Pasture	37,674	2.95%
6	Pasture, Hay or other Grassy Areas (e.g. soccer fields)	Pasture	418,041	32.69%
7	Drought Deciduous Open Woodland	Forest	14,327	1.12%
8	Drought Deciduous Dense Woodland	Forest	17,333	1.36%
9	Deciduous, Evergreen Coastal and Mixed Forest or Shrubland with Succulents	Forest	1,152	0.09%
10	Semi-Deciduous and Drought Deciduous Forest on Alluvium and Non-Carbonate Substrates	Forest	65,234	5.10%
11	Semi-Deciduous and Drought Deciduous Forest on Karst (includes semi-evergreen forest)	Forest	50,751	3.97%
12	Drought Deciduous, Semi-deciduous and Seasonal Evergreen Forest on Serpentine	Forest	7,084	0.55%
13	Seasonal Evergreen and Semi-Deciduous Forest on Karst	Forest	83,460	6.53%
14	Seasonal Evergreen and Evergreen Forest	Forest	248,621	19.44%
15	Seasonal Evergreen Forest with Coconut Palm	Forest	1,098	0.09%

ID	Land Cover Description	Modeled Landuse	Area (ac)	%
16	Evergreen and Seasonal Evergreen Forest on Karst	Forest	9,561	0.75%
17	Evergreen Forest on Serpentine	Forest	13,303	1.04%
18	Elfin, Sierra Palm, Transitional and Tall Cloud Forest	Forest	19,325	1.51%
19	Emergent Wetlands Including Seasonally Flooded Pasture	Wetland	11,671	0.91%
20	Salt or Mud Flats	Wetland	1,528	0.12%
21	Mangrove	Wetland	13,828	1.08%
22	Seasonally Flooded Savannahs and Woodlands	Wetland	1,704	0.13%
23	Pterocarpus Swamp	Wetland	574	0.04%
24	Tidally Flooded Evergreen Dwarf-Shrubland and Forb Vegetation	Wetland	254	0.02%
25	Quarries	Barren	706	0.06%
26	Coastal Sand and Rock	Barren	1,675	0.13%
27	Bare Soil (including bulldozed land)	Barren	9,057	0.71%
28	Water - Permanent	Water	12,138	0.95%
39	Elfin and Sierra Palm Cloud Forest	Forest	3,651	0.29%
		TOTAL:	**1,278,899**	**100.00%**

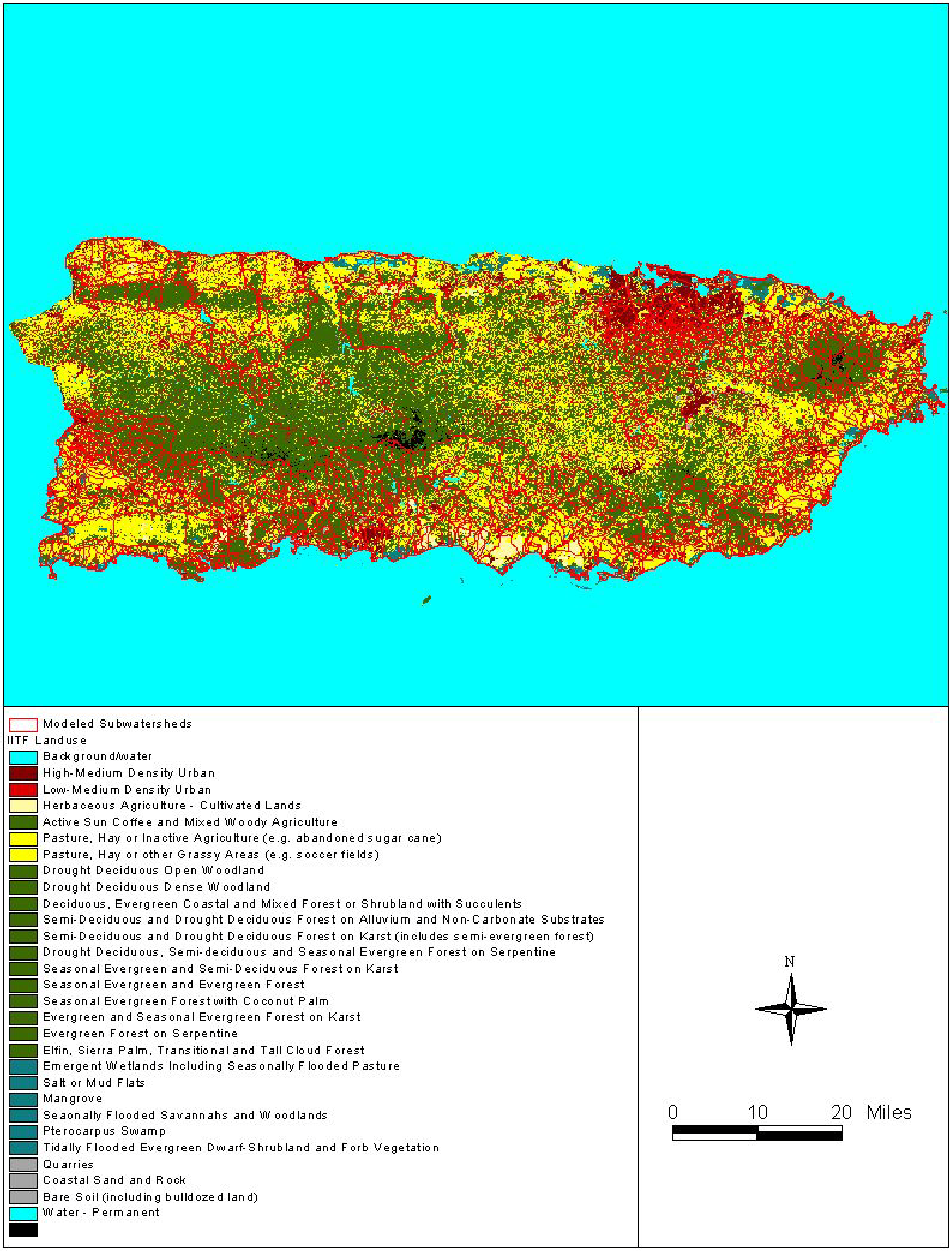

Figure 4-2. Land cover distribution in the study area.

4.1.2.3 Hydrologic Representation

Hydrologic representation refers to the LSPC modules or algorithms used to simulate hydrologic processes (e.g., surface runoff, evapotranspiration, and infiltration). The LSPC PWATER (water budget simulation for pervious land segments) and IWATER (water budget simulation for impervious land segments) modules, which are identical to those in HSPF, were used to represent hydrology for all pervious and impervious land units (Bicknell et al. 1996). Designation of key hydrologic parameters in the PWATER and IWATER modules of LSPC were required. These parameters are associated with infiltration, groundwater flow, and overland flow. U.S. Department of Agriculture, Natural Resources Conservation Service STATSGO Soils Database served as a starting point for designating infiltration and groundwater flow parameters. STATSGO soils based on data circa 1994 are shown in Figure 4-3. For parameter values not easily derived from these sources, documentation on recent HSPF applications was reviewed. Starting values were refined through the hydrologic calibration process (described in Section 4.1.3.1).

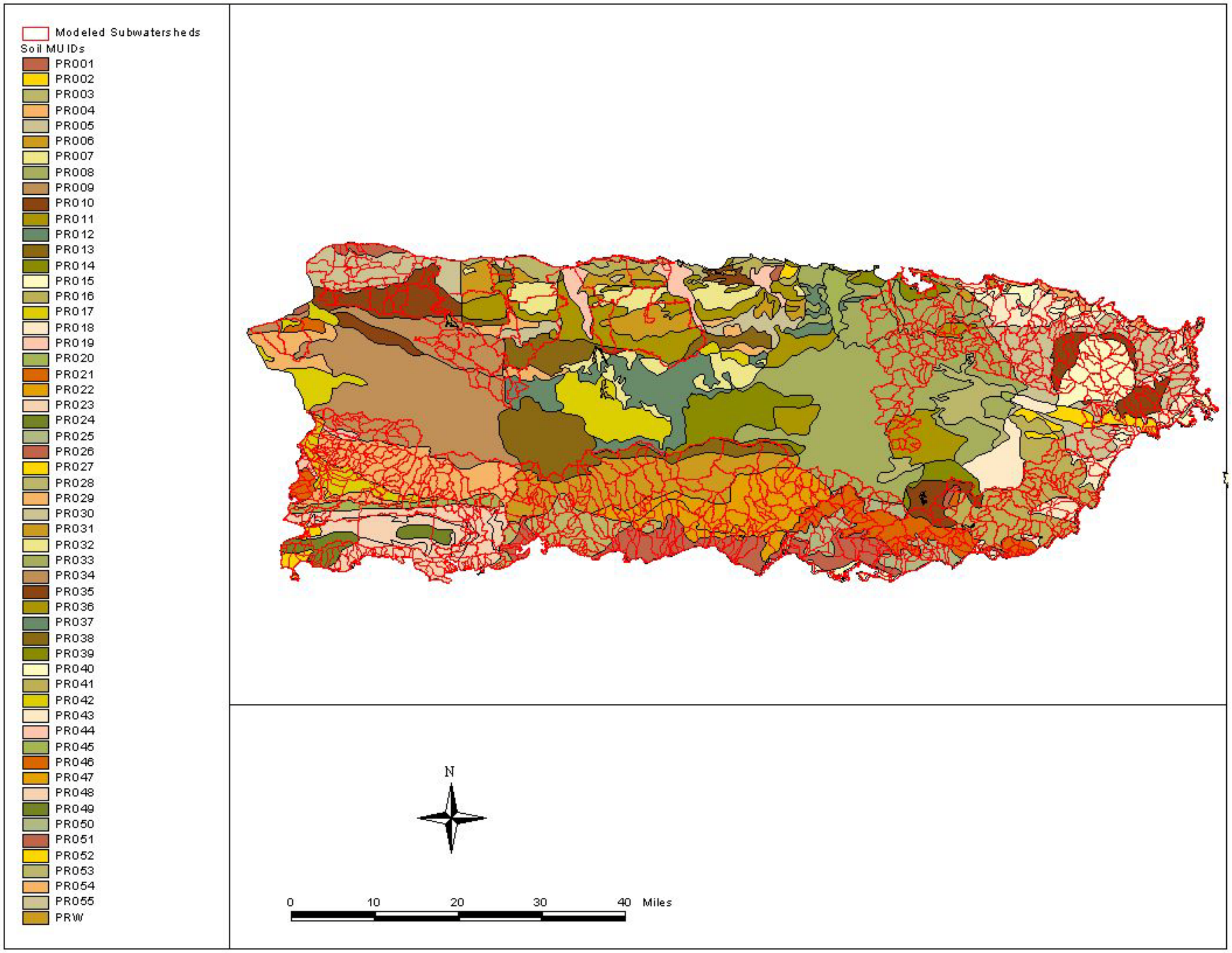

Figure 4-3. STATSGO soil data used in the LSPC watershed model.

4.1.2.4 Meteorological Representation

Meteorological data are a critical component of the watershed model, and appropriate representation of precipitation and evapotranspiration are required to develop a valid modeling system. These data provide necessary input to LSPC algorithms for hydrologic and water quality representation. Meteorological data have been accessed for forty-nine weather stations in an effort to develop the most representative data set for the study area. Weather station attributes are listed in Table 4-3, and the locations of these sources are shown in Figure 4-4. Hourly precipitation and minimum and maximum daily temperature records were obtained from Earth Info's weather CD set for the modeling time period . The original source of the data is the National Climatic Data Center from 1995 to 2004.

LSPC requires appropriate precipitation and potential evapotranspiration data. In general, hourly precipitation data are recommended for hydrologic modeling to help assess pollutant loading (although in some cases, such as small, flashy, highly urbanized watersheds 15-minute data might be necessary). Therefore, only weather stations with hourly recorded data have been considered thus far in the process of selecting precipitation data. Rainfall-runoff processes for each subwatershed were driven by precipitation data from the most representative station. Meteorological data from forty-nine stations in and around the study area were assessed for the watershed model.

During the processing phase of the assessment, gaps in data were identified in addition to unreliable values that could misrepresent observed conditions. Missing and unreliable values were encountered frequently in the precipitation and temperature data sets. Missing values were patched using a program that fills missing values with data from surrounding stations, and unreasonable values were deleted to allow for patching. The patched meteorological data were subsequently formatted for use in the modeling effort.

Table 4-2. Attributes of weather stations represented in the watershed model

Station ID	Station Name	Elevation (ft)	Assessment Unit ID	Lat (dd)	Long (dd)	Evaporation data available	Precipitation data available	Temperature data available
660040	ACEITUNA	2140	PRSL160A	18.150556	-66.493333	NO	Daily	NO
660061	ADJUNTAS SUBSTATION	1830	Not within study area	18.174722	-66.797778	Daily	Daily	Daily
660152	AGUIRRE	25	UCW--7	17.955556	-66.222222	Daily	Daily	Daily
660426	ARECIBO OBSERVATORY	1060	UNC--2	18.349722	-66.752500	NO	Daily	Daily
661345	CALERO CAMP	279	UNC--3	18.470556	-67.115833	NO	Daily	NO
661590	CANOVANAS	30	PRER14B	18.379167	-65.893889	NO	Daily	Daily
662336	CERRO MARAVILLA	4002	PRSE61A	18.154722	-66.561944	NO	Daily	Daily
662801	COLOSO	40	Not within study area	18.380833	-67.156944	NO	Daily	Daily
663023	CORRAL VIEJO	574	PRSR59A--1	18.083611	-66.654722	NO	Daily	NO
663431	DOS BOCAS	200	Not within study area	18.338056	-66.667500	NO	Daily	Daily
663532	ENSENADA 1 W	213	UVL-E	17.974722	-66.946667	NO	Daily	NO
663904	GUAJATACA DAM	663	PRNR3A1	18.396389	-66.924444	NO	Daily	NO

Station ID	Station Name	Elevation (ft)	Assessment Unit ID	Lat (dd)	Long (dd)	Evaporation data available	Precipitation data available	Temperature data available
664126	GUAYABAL	370	PRSE60A	18.074167	-66.496667	NO	Daily	NO
664193	GUAYAMA 2 E	72	PRSE48A	17.978611	-66.087222	NO	Daily	Daily
664276	GURABO SUBSTATION	160	Not within study area	18.258333	-65.992222	Daily	Daily	Daily
664330	HACIENDA CONSTANZA	480	PRWR79A	18.216667	-67.083333	NO	Daily	NO
664702	ISABELA SUBSTATION	420	UNC--3	18.465278	-67.052500	Daily	Daily	Daily
664867	JAJOME ALTO	2385	PRSR54A--3	18.069444	-66.143056	NO	Daily	Daily
665020	JUANA DIAZ CAMP	262	PRSE60A	18.051389	-66.498611	NO	Daily	Daily
665097	LAJAS SUBSTATION	90	UVL-E	18.033056	-67.072222	Daily	Daily	Daily
665693	MAGUEYES ISLAND	12	UCW--1	17.972222	-67.046111	NO	Daily	Daily
665807	MANATI 2 E	250	Not within study area	18.430833	-66.466111	NO	Daily	Daily
665908	MARICAO 2 SSW	2832	PRWR77C	18.151111	-66.988889	NO	Daily	Daily
665911	MARICAO FISH HATCHERY	1500	PRWR77C	18.172500	-66.987222	NO	Daily	NO
666073	MAYAGUEZ CITY	74	UCW--23	18.187500	-67.137778	NO	Daily	Daily
666083	MAYAGUEZ AIRPORT	38	Not within study area	18.253889	-67.148611	NO	Daily	Daily
666361	MORA CAMP	410	UNC--3	18.473611	-67.028889	NO	Daily	NO
666805	PARAISO	360	PREE22A	18.265000	-65.720833	NO	Daily	NO
666983	PENUELAS 1 NE	510	PRSR65A--1	18.061389	-66.711944	NO	Daily	NO
666992	PICO DEL ESTE	3448	PREE22A	18.270833	-65.759167	NO	Daily	Daily
667292	PONCE 4 E	70	PRSE60A	18.025556	-66.525278	Daily	Daily	Daily
668144	RIO BLANCO LOWER	130	PRER30A	18.243889	-65.785278	NO	Daily	NO
668306	RIO PIEDRAS EXP STA	92	PREE13A2	18.390556	-66.054167	Daily	Daily	Daily
668536	SABANA GRANDE 2 ENE	850	PRWR77I	18.088889	-66.930000	NO	Daily	NO
668812	SAN JUAN INTL AP	9	PREE13A3	18.432500	-66.010833	NO	Daily	Daily
668815	SAN LORENZO 3 S	510	Not within study area	18.151667	-65.958889	NO	Daily	NO
668940	SANTA ISABEL 2 ENE	30	UCW--12	17.969167	-66.377222	NO	Daily	NO
668955	SANTA RITA	75	PRSR69A1	18.009444	-66.884722	NO	Daily	NO
669521	TRUJILLO ALTO 2 SSW	115	PRER14A1	18.328333	-66.016389	NO	Daily	Daily
669774	VILLALBA 1 E	430	PRSL160A	18.125833	-66.497500	NO	Daily	NO
669860	YAUCO 1 NW	180	PRSR68A	18.043611	-66.860556	NO	Daily	NO
PR0988	BOTIJAS 2 OROCOVIS	2230	Not within study area	18.198056	-66.353056	NO	Hourly	Hourly
PR1901	CAYEY 1 E	1370	Not within study area	18.111667	-66.149444	NO	Hourly	Hourly
PR3113	CUBUY	1970	PRER14B	18.270556	-65.868056	NO	Hourly	NO
PR3657	FAJARDO	30	PREE22A	18.310278	-65.663056	NO	Hourly	Hourly
PR5258	LAS PIEDRAS 1 N	270	Not within study area	18.196389	-65.865000	NO	Hourly	Hourly
PR6942	PENA POBRE NAGUABO	330	Not within study area	18.219722	-65.826111	NO	Hourly	Hourly
PR8881	SAN SEBASTIAN 2 WNW	170	outside of study area	18.346944	-67.011667	NO	Hourly	Hourly
PR9829	YABUCOA 1 NNE	30	PREE35A	18.062778	-65.873611	Hourly	Hourly	Hourly

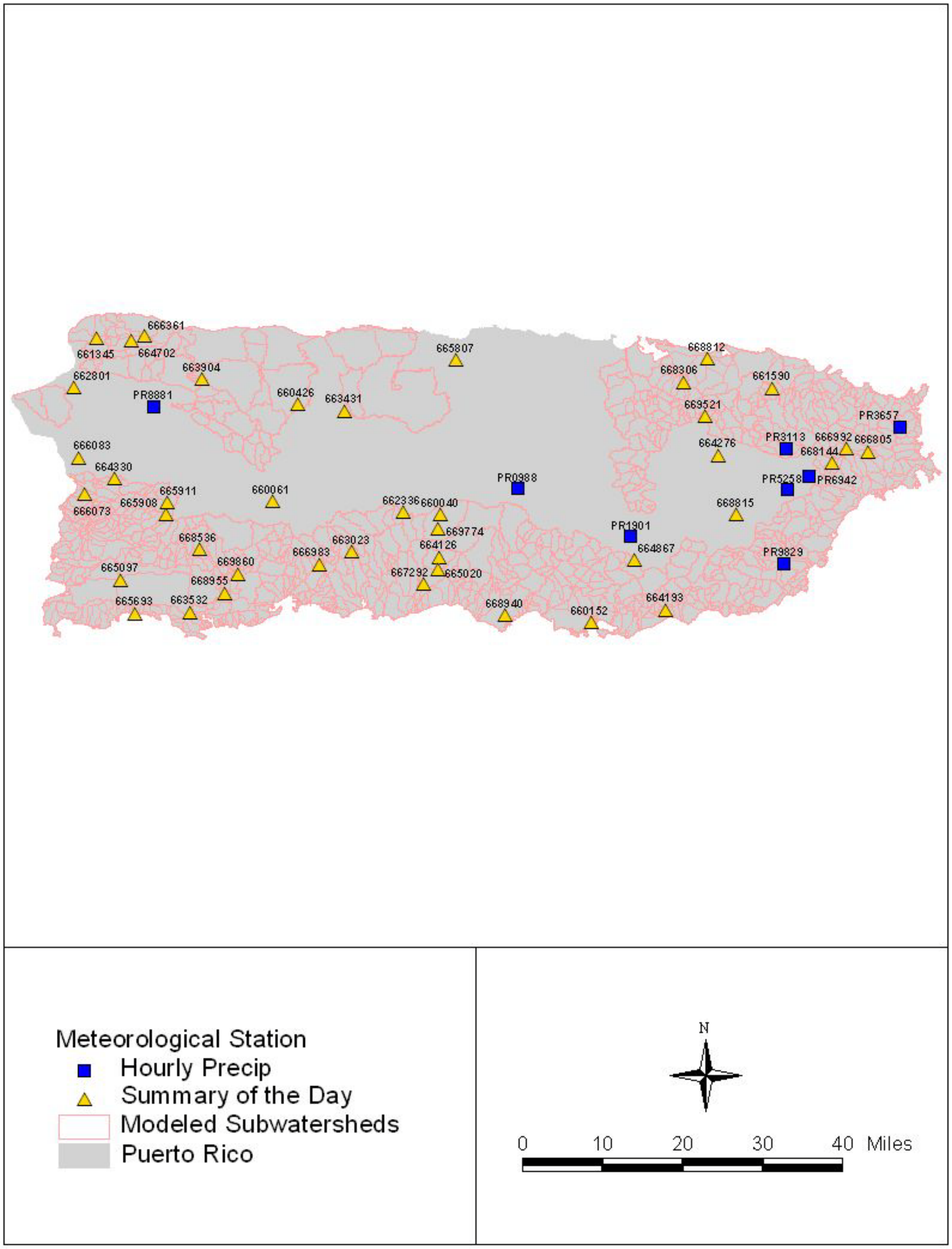

Figure 4-4. Weather stations used in the watershed modeling process.

Potential evapotranspiration was calculated using the Hamon method. This method generates daily potential evapotranspiration (inches) using air temperature, a monthly variable coefficient, the number of hours of sunshine (computed from latitude), and absolute humidity (computed from air temperature). The computations are based on the Hamon (1961) formula:

$$PET = CTS \times DYL \times DYL \times VDSAT$$

where

PET = daily potential evapotranspiration (in inches)
CTS = monthly variable coefficient
DYL = possible hours of sunshine, in units of 12 hours, computed as a function of latitude and time of year
$VDSAT$ = saturated water vapor density (absolute humidity) at the daily mean air temperature (g/cm^3)

$$VDSAT = (216.7 \times VPSAT) / (TAVC + 273.3)$$

where

$VPSAT$ = saturated vapor pressure at the air temperature
$TAVC$ = mean daily air temperature, computed from the daily max-min data (C)

$$VPSAT = 6.108 \times \mathrm{EXP}((17.26939 \times TAVC) / (TAVC + 237.3))$$

Hamon (1961) suggests a constant value of 0.0055 for CTS.

A sine function is used to disaggregate the daily *PET* over the daylight hours. Daylight hours are computed as a function of date and latitude (and the shape of the earth).

The final set of LSPC weather files created included hourly precipitation and calculated potential evapotranspiration for the time period starting on 1/1/1980 through 12/31/2006. The model is run using an hourly time-step.

4.1.2.5 Pollutant Representation

On the basis of analysis of the water quality data available in the study area and potential sources listed with the impairment, possible sources of bacteria include major and minor municipal point sources, landfills, collection system failure, urban runoff/storm sewers, minor industrial point sources, confined animal feeding operations, agricultural practices, and onsite wastewater systems.

The primary pollutant represented in the watershed model to estimate loading is fecal coliform bacteria. Loading processes for pollutants were represented for each land unit using the LSPC PQUAL (simulation of quality constituents for pervious land segments) and IQUAL (simulation of quality constituents for impervious land segments) modules, which are identical to those in HSPF. These modules simulate the accumulation of bacteria on the land surface and removal during overland flow, which is simulated as being removed at a rate related to the volume of water flowing over the land surface.

Point Source Representation

Point source contributions of flow and bacteria were incorporated into the model to represent the sources described in Section 2.3. During calibration, representative flow and pollutant concentrations obtained from discharge monitoring data were used. During the baseline condition, permitted flows and concentrations were used to represent the worst case condition allowable under permit limits.

Nonpoint Source Representation

The watershed model distributes hydrologic and pollutant loading parameters on the basis of land use type to appropriately represent hydrologic variability throughout the watershed. This variability can be influenced by land use-specific surface and subsurface characteristics. It is also necessary to represent variability in pollutant loading, which is highly correlated to land practices. As discussed in Section 4.1.2.2, land cover data from IITF were used to configure the LSPC model. LSPC model algorithms that simulate hydrologic and pollutant loading processes for pervious and impervious lands were then applied to the corresponding land units.

Surface and subsurface hydrologic behavior drives pollutant transport in the watershed. On the basis of the distribution of rainfall between the surface and subsurface components, a quantity of bacteria is washed off into a stream reach. Here, it is subject to decay as it travels through the simulated stream network.

Bacteria were modeled as a pollutant that builds up and washes off. LSPC can simulate pollutants as either sediment-associated or using a buildup-washoff relationship. To simulate bacteria, hydrology must first be simulated and calibrated. Once this is complete, accumulation rates for the land surface are then assigned to identify the quantity available for washoff. As rainfall removes the bacteria from the land surface, it is discharged to receiving waters proportional to the overland flow.

Fecal coliform loading rates were obtained using information from EPA's Bacterial Indicator Tool (U.S. Environmental Protection Agency, 2001), which is a spreadsheet that estimates the bacteria contribution from multiple sources, including Foresty, Barren Land, and Wetlands and as described in Section 2.3.

Thomann and Mueller (1987) present a range of die-off rates for different organisms and conditions. The average die-off rate for coliform bacteria in freshwater is 0.8 1/day. A slightly lower and more conservative value of 0.7 1/day was used in the model.

4.1.3 Watershed Model Calibration and Validation

After initially configuring the watershed model, model calibration and validation for hydrology and water quality was performed. Calibration refers to the adjustment or finetuning of modeling parameters to reproduce observations. Validation is performed for different monitoring stations without further adjustments to ensure that the model represents other locations as well as it does at the original calibration locations and periods. The years 1995–1999 were used to calibrate hydrology and water quality. The 2000–2004 period was used for validation. Selection criteria for these time periods are discussed below.

4.1.3.1 Hydrology Calibration and Validation

Hydrologic calibration was performed after the initial model setup. For LSPC, calibration is an iterative procedure of parameter evaluation and refinement as a result of comparing simulated and observed values of interest. It is required for parameters that cannot be deterministically and uniquely evaluated from topographic, climatic, physical, and chemical characteristics of the watershed and compounds of interest. Calibration is based on several years of simulation to evaluate parameters under a variety of climatic conditions. The calibration procedure results in parameter values that produce the best overall agreement between simulated and observed flows throughout the calibration period. One USGS flow gaging station is presented here as an example of calibration and validation of the LSPC model. The *Rio Guanajibo Nr Hormigueros, PR* station, or USGS 50138000, and its drainage area and elevation are listed in Table 3-1. It is the station used to illustrate the comparison in this section.

Calibration and validation years were selected on the basis of an examination of annual precipitation variability and the availability of observation data. The periods were determined to represent hydrologic conditions common to the region with respect to seasonal flow regimes. Calibration for these conditions is necessary to ensure that the model accurately predicts the seasonal range of conditions over the entire simulation period. During calibration, parameters influencing the simulation of runoff, infiltration, and evapotranspiration were adjusted depending on land use and soil type. Modeling parameters were varied to mirror observed temporal trends and soil and land cover characteristics. Tetra Tech attempted to keep the modeling parameters within the guidelines included in the BASINS Technical Note 6 (USEPA 2000). Key considerations in the hydrology calibration included the overall water balance, high-flow and low-flow distribution, storm flow volumes and timing, and seasonal variation. At least three criteria for goodness of fit were used for calibration: volumetric comparison, graphical comparison, and the relative error method. Water budget graphical comparisons for the calibration and validation periods are shown in Figure 4-5, Figure 4-6, and Appendix C. In addition, summary statistical comparisons for calibration and validation periods are shown on Table 4-3, Table 4-4, and Appendix C. Given the critical conditions of the TMDL, the most relevant criteria for evaluating the goodness of fit for this calibration were the percent error in total volume, 50 percent lowest flows, and 10 percent highest flows. The error for total volume is calculated by summing the modeled and observed volumes over the calibration period and deriving the percent increase (+) or decrease (-) relative to observed. Similarly, the highest and lowest 10% of daily flows are summed and compared. The errors are also well within the recommended criteria.

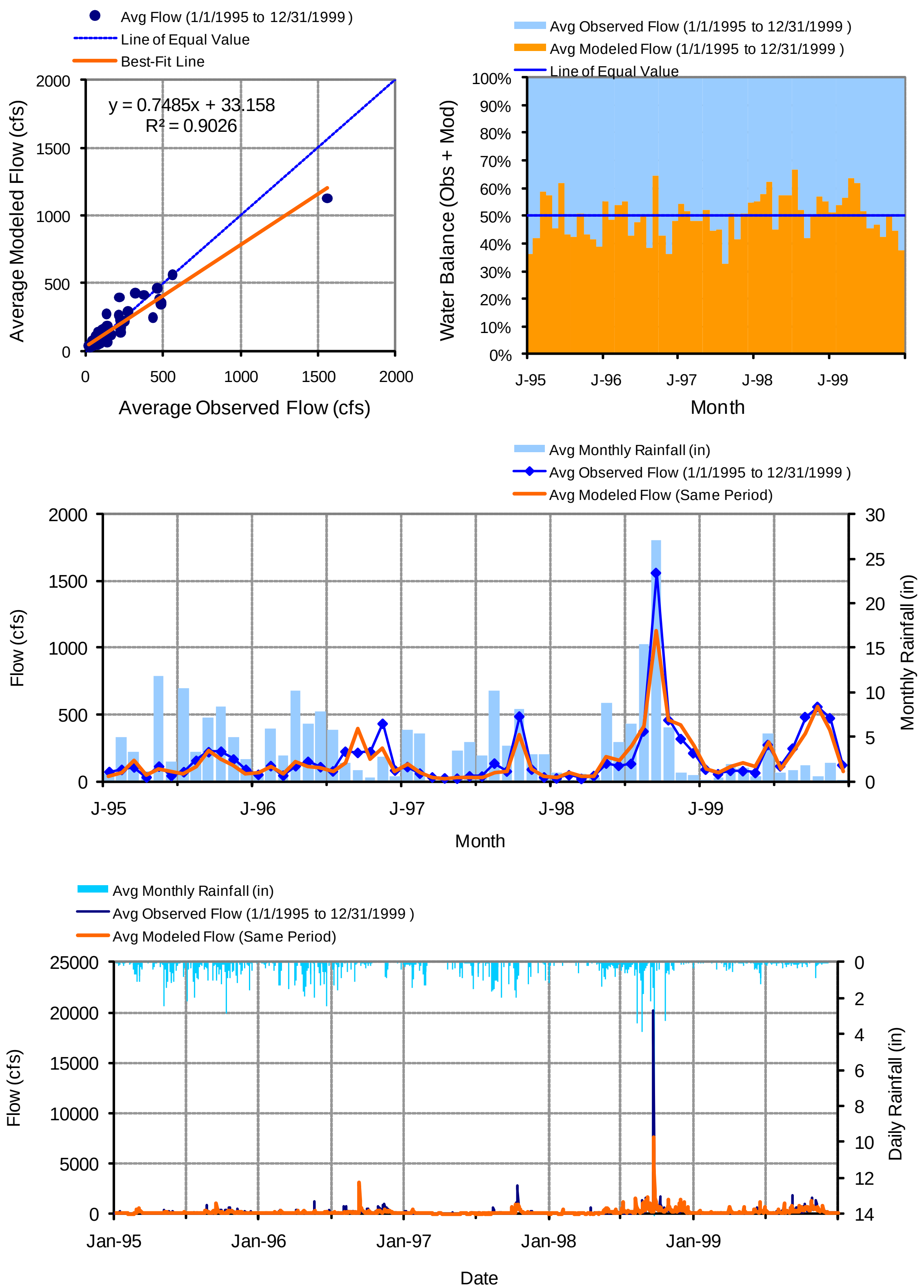

Figure 4-5. LSPC hydrology calibration for 1995–1999 at USGS 50138000: Rio Guanajibo Nr Hormigueros, Puerto Rico.

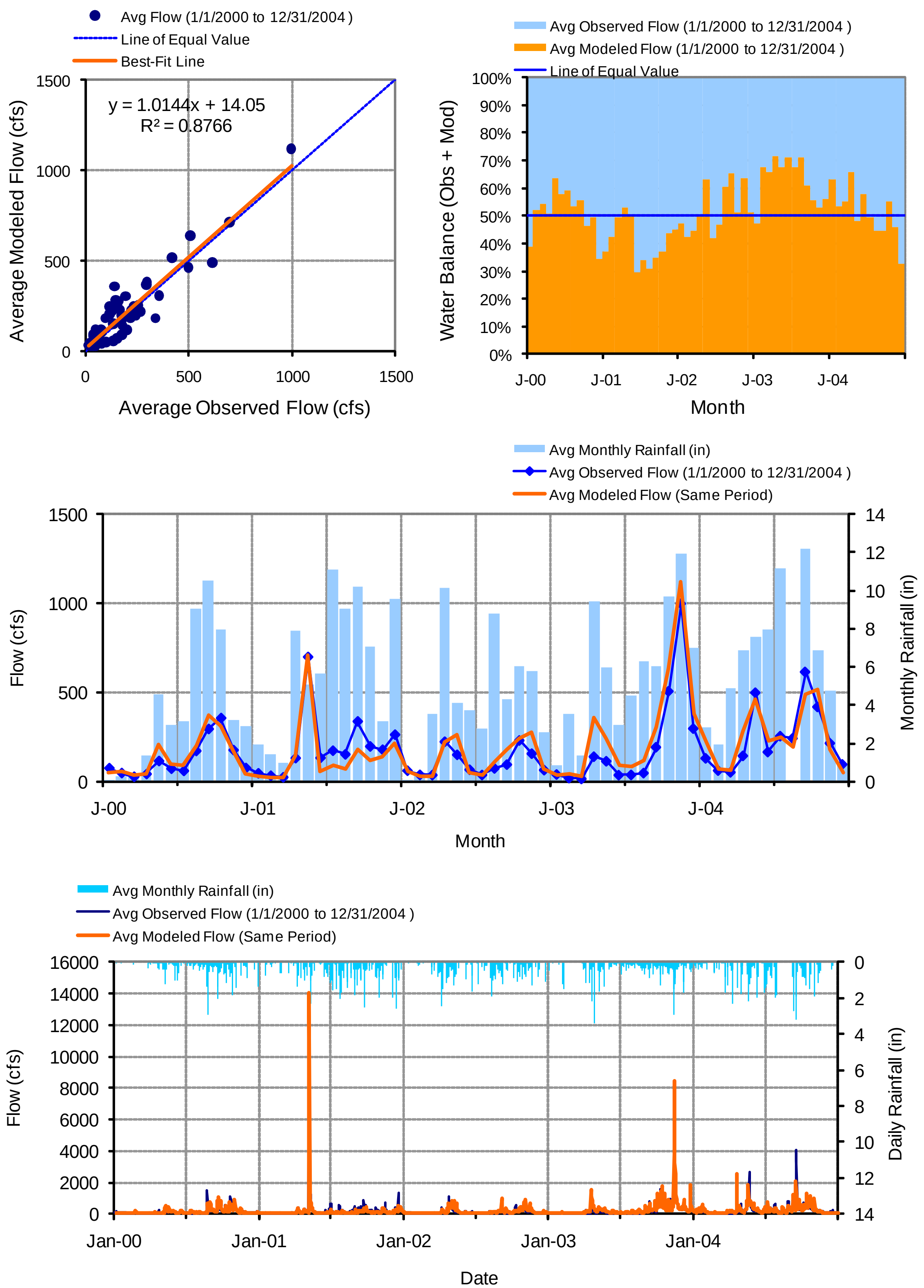

Figure 4-6. LSPC hydrology validation for 2000–2004 at USGS 50138000: Rio Guanajibo Nr Hormigueros, Puerto Rico.

Table 4-3. Water budget statistical comparison for 1995–1999 at 50138000: Rio Guanajibo Nr Hormigueros, Puerto Rico.

LSPC Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM SUBBASIN 14038 5-Year Analysis Period: 1/1/1995 - 12/31/1999 Flow volumes are normalized, with total observed as 100		USGS 50138000 Warning: Javascript must be enabled to use all the features on this page! Hydrologic Unit Code: Latitude: Longitude: Drainage Area (sq-mi):		
Total Simulated In-stream Flow:	**93.63**	Total Observed In-stream Flow:		**100.00**
Total of simulated highest 10% flows:	**40.52**	Total of Observed highest 10% flows:		**47.13**
Total of Simulated lowest 50% flows:	**13.81**	Total of Observed Lowest 50% flows:		**12.80**
Simulated Summer Flow Volume (months 7-9):	**34.72**	Observed Summer Flow Volume (7-9):		**39.17**
Simulated Fall Flow Volume (months 10-12):	**33.25**	Observed Fall Flow Volume (10-12):		**38.02**
Simulated Winter Flow Volume (months 1-3):	**10.67**	Observed Winter Flow Volume (1-3):		**9.66**
Simulated Spring Flow Volume (months 4-6):	**14.99**	Observed Spring Flow Volume (4-6):		**13.15**
Total Simulated Storm Volume:	**15.98**	Total Observed Storm Volume:		**22.01**
Simulated Summer Storm Volume (7-9):	**8.01**	Observed Summer Storm Volume (7-9):		**11.75**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	*1995-1999*	*2000-2004*
Error in total volume:	-6.37	10	-1.43	7.35
Error in 50% lowest flows:	7.90	10	-1.60	-3.91
Error in 10% highest flows:	-14.02	15	2.26	1.75
Seasonal volume error - Summer:	-11.34	30	13.27	-2.52
Seasonal volume error - Fall:	-12.55	30	4.49	12.42
Seasonal volume error - Winter:	10.43	30	-18.21	13.31
Seasonal volume error - Spring:	13.95	30	1.90	6.11
Error in storm volumes:	-27.37	20	1.13	12.07
Error in summer storm volumes:	-31.82	50	3.16	15.42
Nash-Sutcliffe Coefficient of Efficiency, E:	0.609	Model accuracy increases	0.688	0.814
Baseline adjusted coefficient (Garrick), E':	0.498	as E or E' approaches 1.0	0.517	0.549

Table 4-4. Water budget statistical comparison for 2000–2004 at USGS 50138000: Rio Guanajibo Nr Hormigueros, Puerto Rico.

LSPC Simulated Flow		Observed Flow Gage		
REACH OUTFLOW FROM SUBBASIN 14038 5-Year Analysis Period: 1/1/2000 - 12/31/2004 Flow volumes are normalized, with total observed as 100		USGS 50138000 Warning: Javascript must be enabled to use all the features on this page! Hydrologic Unit Code: Latitude: Longitude: Drainage Area (sq-mi):		
Total Simulated In-stream Flow:	**109.39**	Total Observed In-stream Flow:		**100.00**
Total of simulated highest 10% flows:	**49.09**	Total of Observed highest 10% flows:		**45.31**
Total of Simulated lowest 50% flows:	**14.38**	Total of Observed Lowest 50% flows:		**13.97**
Simulated Summer Flow Volume (months 7-9):	**26.26**	Observed Summer Flow Volume (7-9):		**26.56**
Simulated Fall Flow Volume (months 10-12):	**42.49**	Observed Fall Flow Volume (10-12):		**40.35**
Simulated Winter Flow Volume (months 1-3):	**7.68**	Observed Winter Flow Volume (1-3):		**6.95**
Simulated Spring Flow Volume (months 4-6):	**32.96**	Observed Spring Flow Volume (4-6):		**26.15**
Total Simulated Storm Volume:	**22.99**	Total Observed Storm Volume:		**19.60**
Simulated Summer Storm Volume (7-9):	**4.81**	Observed Summer Storm Volume (7-9):		**5.07**
Errors (Simulated-Observed)	*Error Statistics*	*Recommended Criteria*	*1995-1999*	*2000-2004*
Error in total volume:	9.39	10	-1.43	7.35
Error in 50% lowest flows:	2.92	10	-1.60	-3.91
Error in 10% highest flows:	8.34	15	2.26	1.75
Seasonal volume error - Summer:	-1.12	30	13.27	-2.52
Seasonal volume error - Fall:	5.32	30	4.49	12.42
Seasonal volume error - Winter:	10.60	30	-18.21	13.31
Seasonal volume error - Spring:	26.02	30	1.90	6.11
Error in storm volumes:	17.31	20	1.13	12.07
Error in summer storm volumes:	-5.18	50	3.16	15.42
Nash-Sutcliffe Coefficient of Efficiency, E:	0.788	Model accuracy increases	0.688	0.814
Baseline adjusted coefficient (Garrick), E':	0.444	as E or E' approaches 1.0	0.517	0.549

4.1.4 Water Quality Calibration

After hydrology was sufficiently calibrated, water quality calibration was performed. The water quality calibration consisted of running the watershed model, comparing water quality output to available water quality observation data, and adjusting pollutant loading and in-stream water quality parameters within a reasonable range. Recent data were used for the calibration process to capture current conditions. Specifically, the years 1995–1999 were used for calibration, and 2000–2004 were used to validate the model to maintain consistency with the hydrology calibration.

The water quality data obtained from stations shown in Figure 3-1 were used for LSPC water quality calibration and validation. These stations were selected on the basis of the quantity, age, and temporal resolution of data. Predicted pollutant concentrations were graphically compared to observed values. Once the model was calibrated for flow and water quality, it was validated by comparing model results representing another time period with inherently different hydrologic conditions. Table 4-5 presents the set of calibrated fecal coliform inputs to the model by landuse.

The model validation was performed to test the calibrated parameters at different locations or for different periods, without further adjusting model parameters. If the model exhibited a poor validation, the calibration process was revisited. After completing the calibration and validation at selected locations, a calibrated data set containing parameter values for each modeled land use and soil type was obtained. The validation between ambient data and LSPC results was rudimentary in nature, based on the infrequency of data collection. All fecal coliform monitoring data used were collected quarterly. Therefore, the modeling data was verified using simple comparisons to the fecal coliform monitoring data by visual comparisons of computed versus measured data. The model captures the spatial and temporal dynamics and fecal coliform concentrations, including the cause and effect relationships between sources (loads) and water column concentrations. The model also over-predicted fecal coliform concentrations during certain low flows when compared to the ambient monitoring values. The calibrated LSPC surface accumulation rate and limit for each modeled landuse is presented in Table 4-6. Water quality calibration results at the USGS station 50138000 (to coincide with the flow calibration shown in the previous section) are shown in Figure 4-7. Validation results are shown in Figure 4-8. Additional calibration and validation graphs can be found in Appendix C.

Overall, the water quality calibration at this location shows that the LSPC model well represents the study area. The observed seasonal trends for bacteria are represented by the model, and simulation data between monitoring points captures expected variability from rainfall events and dry periods where point sources might have increased influence. There is a very large range of observed fecal coliform bacteria concentrations. The model captures most of this variability, although a few of the data observed are higher and some are lower. Although there are always inherent limitations on modeling of fecal coliform bacteria, the water quality calibration is considered successful.

Table 4-5. Calibrated LSPC accumulation rate and limit of fecal coliform bacteria by modeled landuse

Region	Land Use ID	Landuse	Surface Accumulation (#/ac/day)	Surface Accumulation Limit (#/ac/day)
Northwest (1)	0	Water	0.00E+00	0.00E+00
Northwest (1)	1	Forest	6.26E+07	1.13E+08
Northwest (1)	2	Agriculture	5.38E+10	2.69E+11
Northwest (1)	3	Pasture	4.17E+10	2.09E+11
Northwest (1)	4	Wetland	6.26E+07	1.13E+08
Northwest (1)	5	Barren	2.00E+05	3.60E+05
Northwest (1)	6	Urban_HighD_Pervious	2.00E+07	1.00E+08
Northwest (1)	7	Urban_LowD_Pervious	1.35E+07	6.75E+07
Northwest (1)	8	Urban_HighD_Impervious	2.00E+07	1.00E+08
Northwest (1)	9	Urban_LowD_Impervious	1.35E+07	6.75E+07
Northwest (2)	0	Water	0.00E+00	0.00E+00
Northwest (2)	1	Forest	6.26E+07	1.13E+08
Northwest (2)	2	Agriculture	5.38E+10	2.69E+11
Northwest (2)	3	Pasture	4.17E+10	2.09E+11
Northwest (2)	4	Wetland	6.26E+07	1.13E+08
Northwest (2)	5	Barren	2.00E+05	3.60E+05
Northwest (2)	6	Urban_HighD_Pervious	2.00E+07	1.00E+08
Northwest (2)	7	Urban_LowD_Pervious	1.35E+07	6.75E+07
Northwest (2)	8	Urban_HighD_Impervious	2.00E+07	1.00E+08
Northwest (2)	9	Urban_LowD_Impervious	1.35E+07	6.75E+07
North	0	Water	0.00E+00	0.00E+00
North	1	Forest	6.26E+07	1.13E+08
North	2	Agriculture	1.99E+12	1.99E+13
North	3	Pasture	1.12E+09	1.12E+10
North	4	Wetland	6.26E+07	1.13E+08
North	5	Barren	2.00E+05	3.60E+05
North	6	Urban_HighD_Pervious	3.00E+08	3.00E+09
North	7	Urban_LowD_Pervious	2.03E+08	2.03E+09
North	8	Urban_HighD_Impervious	3.00E+08	3.00E+09
North	9	Urban_LowD_Impervious	2.03E+08	2.03E+09
East	0	Water	9.11E+03	1.64E+04
East	1	Forest	2.31E+06	4.15E+06
East	2	Agriculture	2.15E+11	3.87E+11
East	3	Pasture	1.15E+10	2.07E+10
East	4	Wetland	2.28E+05	4.10E+05
East	5	Barren	2.28E+05	4.10E+05
East	6	Urban_HighD_Pervious	6.53E+10	1.18E+11
East	7	Urban_LowD_Pervious	2.13E+08	3.83E+08
East	8	Urban_HighD_Impervious	8.25E+11	1.48E+12
East	9	Urban_LowD_Impervious	2.69E+09	4.83E+09
South	0	Water	6.26E+07	1.13E+08
South	1	Forest	6.26E+07	1.13E+08
South	2	Agriculture	1.20E+11	2.17E+11
South	3	Pasture	3.65E+10	6.57E+10

Region	Land Use ID	Landuse	Surface Accumulation (#/ac/day)	Surface Accumulation Limit (#/ac/day)
South	4	Wetland	6.26E+07	1.13E+08
South	5	Barren	2.00E+05	3.59E+05
South	6	Urban_HighD_Pervious	2.00E+07	3.59E+07
South	7	Urban_LowD_Pervious	1.35E+07	2.42E+07
South	8	Urban_HighD_Impervious	2.00E+07	3.59E+07
South	9	Urban_LowD_Impervious	1.35E+07	2.42E+07
West / Southwest	0	Water	0.00E+00	0.00E+00
West / Southwest	1	Forest	6.26E+07	1.13E+08
West / Southwest	2	Agriculture	1.57E+10	2.83E+10
West / Southwest	3	Pasture	4.53E+09	8.15E+09
West / Southwest	4	Wetland	6.26E+07	1.13E+08
West / Southwest	5	Barren	2.00E+05	3.60E+05
West / Southwest	6	Urban_HighD_Pervious	2.00E+07	3.60E+07
West / Southwest	7	Urban_LowD_Pervious	1.35E+07	2.43E+07
West / Southwest	8	Urban_HighD_Impervious	2.00E+07	3.60E+07
West / Southwest	9	Urban_LowD_Impervious	1.35E+07	2.43E+07

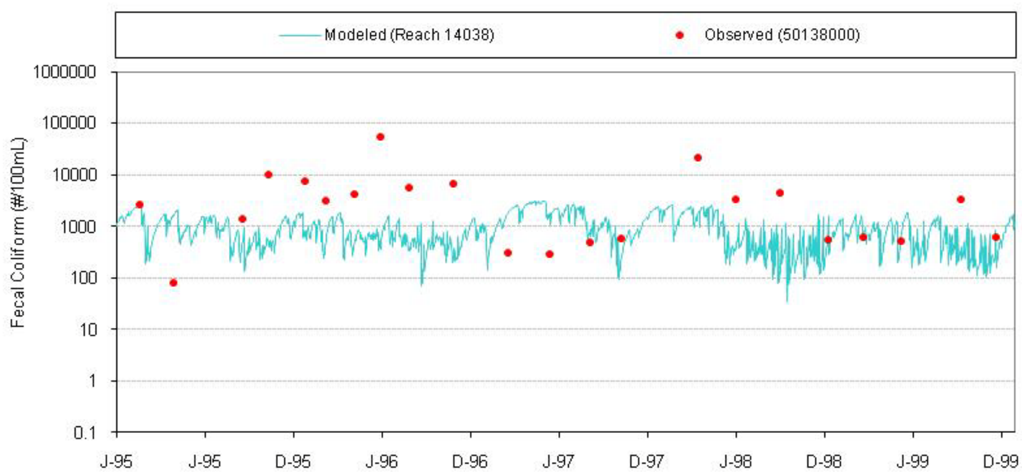

Figure 4-7. Water quality calibration at USGS 50138000: Rio Guanajibo Nr Hormigueros, Puerto Rico.

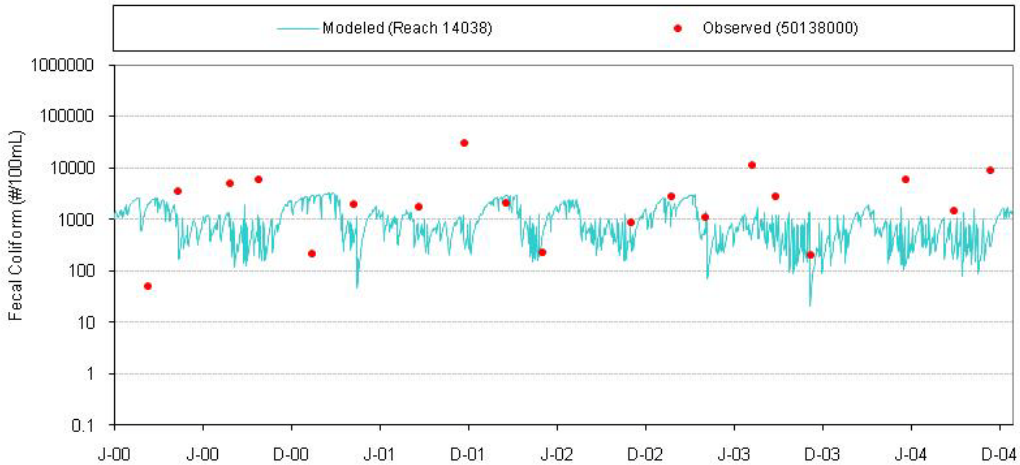

Figure 4-8. Water quality validation at USGS station 50138000: Rio Guanajibo Nr Hormigueros, Puerto Rico.

4.2 Tidal Prism Model

The daily fecal coliform bacteria loads representing all source contributions were introduced to a tidal prism model to predict fecal coliform bacteria levels over time in the tidal portions of the study area. The concept of the tidal prism model is shown in Figure 4-9. The ebb (Q_b) and flood (Q_o) of the tide moves water between locations exchanging and mixing with other water. Apart from this, the amount of freshwater discharge into the embayment (Q_f) is also one of the dominant influences on the transport of fecal coliform bacteria.

The tidal prism method of estimating in-stream fecal coliform bacteria concentrations uses the volume of the waterbody and adjusts for tidal flushing, freshwater inflow and bacteria load (L_f), and bacteria decay (k) to establish the existing conditions in the estuary. The conceptual and mathematical components of the tidal prism model are further described in Appendix B.

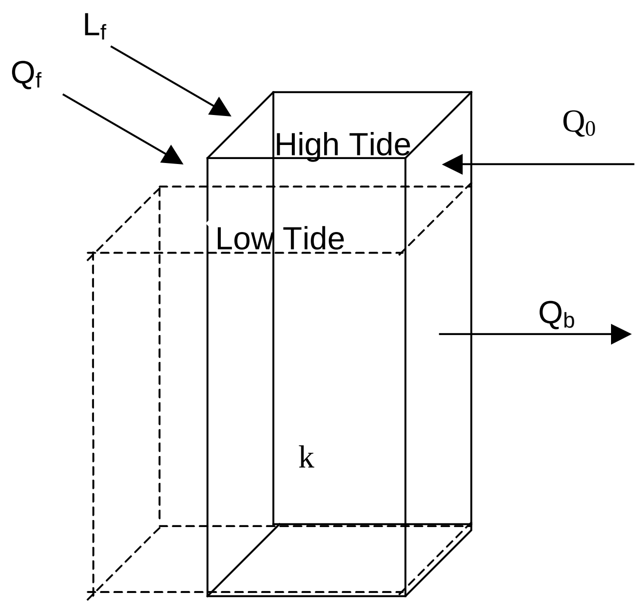

Figure 4-9. Tidal prism model concept.

The tidal portion of the study area was estimated on the basis of data obtained from the USGS. These data estimate the inland extent of the salt wedge, or water of higher salinity than the watershed runoff. The USGS developed preliminary estimates of saltwater intrusion in coastal rivers on the basis of local tide variation data (San Juan, PR station [NOAA/NOS # 9755371]). However, it is acknowledged that these shapefiles are static and do not reflect seasonal patterns. Figure 4-10 illustrates the inland extent of high-salinity water according to USGS data. These data were used to estimate the volume of the tidal prism domain, in conjunction with the Rosgen method of stream geometry estimation, as discussed in Section 4.1.2.1.

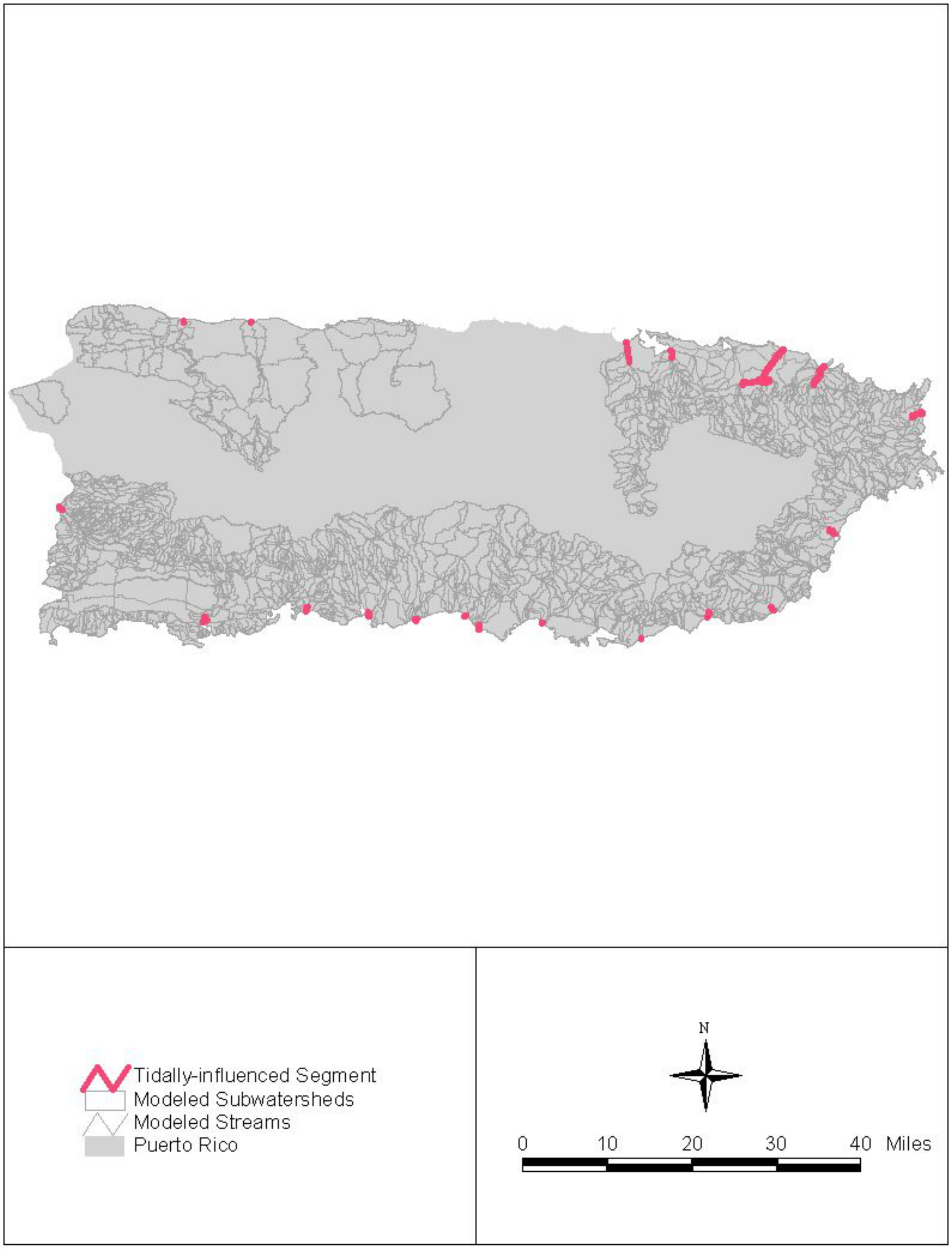

Figure 4-10. USGS Data used to estimate the extent of saltwater intrusion and tidal influence in the study area.

4.3 Assumptions and Limitations

Some of the major underlying assumptions for this analysis include the following:

- The watersheds delineated were based on topographic data and available stream and channel coverages. Data regarding flow diversions to or from other watersheds were not available and therefore not considered in the analysis.
- Regeneration of fecal coliform bacteria is not a significant source.
- After the model was calibrated and validated using representative flows and concentrations for permitted facilities, the permitted facilities' flows and concentrations were set to reflect their permit limits. This was the model run that was compared against the TMDL targets. This is a worst-case scenario of permitted facilities loading.
- All the estimated flows and loads from failing septic systems are assumed to be discharged to the streams. This is a conservative assumption in that it is expected that a portion of these loads will not be able to gain access to the stream reaches.
- The average rate of decay for fecal coliform bacteria (0.7 ^{1}/day) does not vary seasonally or by meteorological conditions. This is a conservative assumption, because the die-off rate will probably be higher in the warm waters of this watershed
- Streams are assumed to be completely mixed, one-dimensional segments with a constant trapezoidal cross-section.

A number of limitations were inherent in the analytical process because of the approach selected. These limitations are identified below. Although these limitations are present, the approach followed successfully resulted in identifying the TMDL. If additional data are collected for the study area, many of these limitations can be addressed.

- Population estimates for the watershed were calculated using 2000 Census block data for Puerto Rico.
- Tidal portions are static and do not reflect seasonal patterns of tidal influences.
- The modeling data was verified by visual comparisons of computed versus measured data because all fecal coliform monitoring data used were collected quarterly.

5 TMDL CALCULATION AND ALLOCATIONS

A TMDL for a given pollutant and waterbody is composed of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for both nonpoint sources and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, to account for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is represented by the equation

$$TMDL = \sum WLAs + \sum LAs + MOS$$

The TMDL is the total amount of pollutant that can be assimilated by the receiving waterbody while still achieving the TMDL target. In TMDL development, allowable loadings from pollutant sources that cumulatively amount to no more than the TMDL must be established; this provides the basis to establish water quality-based controls. TMDLs can be expressed on a mass loading basis (e.g., bacteria counts per day) or as a concentration in accordance with 40 CFR 130.2(l).

5.1 Numeric Target for Fecal Coliform Bacteria

The TMDL target for the study area is a dual target; a geomean of 200 colonies/100 mL or less, and 400 colonies/100 mL or less, not to be exceeded more than 20 percent of the time. This target was selected on the basis of the water quality criteria discussed in Section 2.2. Watershed and tidal segment concentrations were not allowed to exceed these limits for the TMDL condition. TMDL target attainment was assessed at the pour point of each delineated watershed, regardless of water features upstream (e.g small reservoirs) of the pour point. For example, several lakes are listed for fecal coliform bacteria in Table 2-1, and are included in the TMDL analysis. One of the lakes was explicitly modeled (Lago de Cidra), but the remainder were not, and were represented in the landuse modeling as “water,” which does not contribute a bacteria load. Although these features were not explicitly modeled (see Section 4.1.2.1), the load from the surrounding watershed remains the same as if the lakes were to be modeled explicitly since the water component does not provide a bacteria load.

Compliance with the TMDL target was evaluated using the results of LSPC and tidal prism models. The daily time series of in-stream fecal coliform bacteria concentrations were reduced until 80 percent of values were below 400 colonies/100 mL. Then, a moving 5-day geomean of concentrations on consecutive days was calculated. These values were reduced until none of the geomeans were above 200 colonies/100 mL. Attainment of the target was assessed at the pour point of each modeled watershed, in addition to the pour point of the assessment unit. Due to the variability of rainfall patterns in Puerto Rico, a long-duration allocation time period (1/1/1995-12/31/2004) was selected so that rainfall variability could be captured across the study area and the critical conditions encompassed (see Section 2). The time period was selected so that both extreme and minimal precipitation conditions were considered in the TMDL.

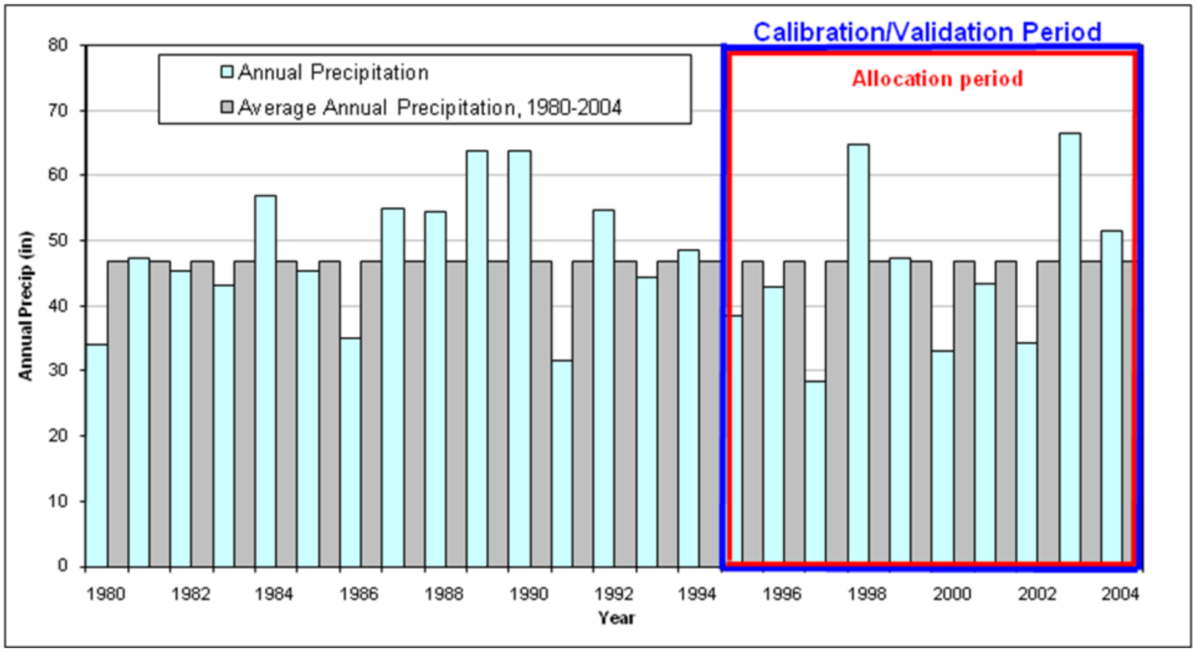

Figure 5-1. Annual precipitation totals between 1980 and 2004, and selected allocation period for the western region (Precip ID Station 665097).

As an example, Figure 5-1 shows annual precipitation at *Lajas Substation, Puerto Rico* (Station number 665097) for the years 1980–2004. The time period selected for TMDL allocations were selected to address data availability and to encompass critical precipitation conditions and thus flow conditions in the watershed. For example, the year 1998 experienced hurricane Georges and provides the wettest year for consideration in the calibration/validation period and the second wettest year in the entire data set available. The year 1997 was the driest one in the calibration/validation period and the third driest year in the entire data set. The year 1999 was relatively average with respect to precipitation. As discussed in Section 3.2, the critical condition in the study area occurs during both high- and low-flow periods. Therefore, an allocation scenario time period that encompassed both conditions within the calibrated and validated modeling timescale was needed for this TMDL. The reason for selecting a relatively short allocation period was to make the allocations more efficient.

The allocation process is iterative and performed in a top-down manner. Assessment units upstream were evaluated first. The sources were reduced until the in-stream concentrations met the TMDL targets, then the next downstream AU was evaluated, and so on. The most stringent target to meet depended on the assessment unit being evaluated. The final step of the allocations was to evaluate the TMDL targets for all AUs for the entire modeling period. All AUs and subwatersheds within the AUs met the required TMDL targets. In general, the critical condition occurs when a large storm follows a very long dry period. During the dry period, the fecal coliform concentrations are elevated because the load from failing septics and point sources are less diluted, and once the storm arrives and generates runoff, the first flush of the bacteria that accumulated on the ground from non-point sources and MS4s is added to the stream.

A 73 percent reduction in overall bacteria loading in the study area met the TMDL targets identified in Section 5.1. Therefore, this is the reduction required to meet the TMDL. The allocations for the bacteria sources are discussed below.

5.2 Margin of Safety

There are two methods for incorporating the MOS (USEPA 1991):

- Implicitly incorporate the MOS using conservative model assumptions to develop allocations
- Explicitly specify a portion of the total TMDL as the MOS and use the remainder for allocations

For the study area, an implicit MOS was incorporated in several ways. Throughout the TMDL development process, conservative assumptions were made to address the implicit component of the MOS (see list of assumptions in Section 4.3). For example, as described in Section 5.1, the TMDL target was assessed at each of the modeled subwatersheds, which are at a finer resolution than the assessment unit. Therefore, local variations in bacteria levels are addressed in the allocation process, which requires additional reductions. In addition, an explicit 10 percent MOS was set-aside from the load capacity of the LA and MS4 allocations for fecal coliform bacteria. The TMDL targets described in Section 5.1 were selected on the basis of the water quality standards discussed previously.

5.3 Fecal Coliform Bacteria TMDLs

The fecal coliform bacteria TMDLs for the study area were developed using the LSPC model, and targets were based on existing water quality criteria, as discussed in Section 2.2. The existing and TMDL bacteria loads were generated from the calibrated LSPC model. The target TMDL values for bacteria were calculated by iteratively adjusting loading rate input until simulated in-stream concentrations achieved water quality standards. A maximum geomean (at least five samples) in-stream concentration of 200 colonies/100 mL of fecal coliform bacteria, with no more than 20 percent of the samples exceeding 400 colonies/100 mL were used as TMDL endpoints, which directly represent the criteria discussed in Section 2.2. As an example, Figure 5-2 illustrates compliance with the water quality targets under TMDL conditions. The target of a maximum geomean (at least five samples) in-stream concentration of 200 colonies/100 mL of fecal coliform bacteria was the most stringent.

Tables 5-1 and 5-2 present baseline and TMDL summaries, respectively, for each of the assessment units. 135 out of the 201 assessment units were not included on the list of impaired waters. However, because these assessment units are in the study area, they were simulated in the LSPC model. On the basis of modeling results, water quality in these assessment units does not meet water quality standards, and thus TMDLs were calculated for these units as well.

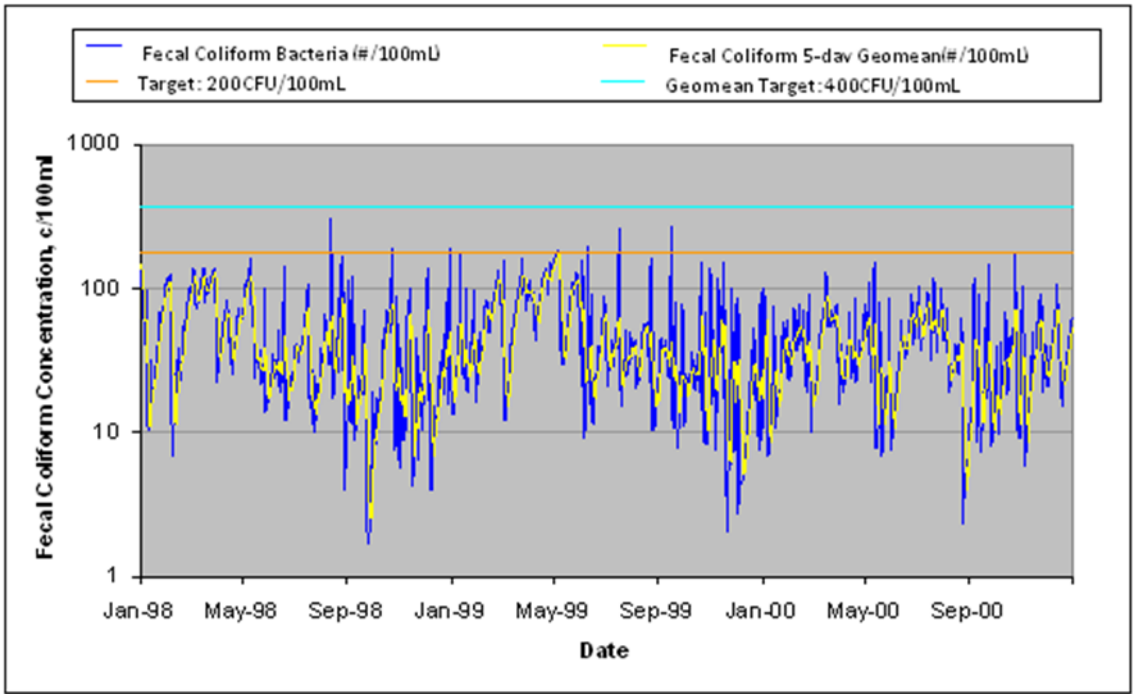

Figure 5-2. Example of daily and 5-day geomean time series under TMDL conditions.

The baseline loads presented for septics in Table 5-1 are the sum of the estimated septics load from Table 2-7 for all subwatersheds that compose the assessment unit. The baseline loads presented for NPDES permits in Table 5-1 are the sum of the permitted loads from Table 2-2 for all facilities in the subwatersheds that compose the assessment unit. The baseline loads presented for MS4 permits in Table 5-1 are the sum of the estimated loads from all MS4 areas in the subwatersheds that compose the assessment unit (see Table 2-3). The baseline loads presented for each land use type in Table 5-1 are the sum of the estimated loads from nonpermitted stormwater (see Table 2-5 and 2-6) and other landuses as calculated by EPA's Bacteria Indicator Tool as described in Section 2.3.2.1.

The TMDL loads presented for septics in Table 5-2 are based on a complete elimination of failing septics load to the streams (i.e. by fixing the failing septic systems so that they perform adequately). The TMDL loads presented for NPDES permits in Table 5-1 are the sum of the WLAs from Table 5-4 for all facilities in the subwatersheds that compose the assessment unit. The TMDL loads presented for MS4 permits in Table 5-2 are the sum of the WLAs from all MS4 areas in the subwatersheds that compose the assessment unit, see Table 5-3. Appendix F of this document include a summary of TMDL allocations and expresses daily loads as the annual loads divided by 365¼. "At this time, TMDLs for only 81 assessment units (35 assessment units on the 303(d) list and 46 assessment units determined to be impaired for fecal coliform) are being finalized within 65 subwatersheds (see Tables 5-1 and 5-2)."

Table 5-1. Baseline summary by assessment unit

Source		UNC--3 (#/yr)	PRNL3A1 (#/yr)	PRNR3A2 (#/yr)	PRNQ3B (#/yr)	UNC--2 (#/yr)	PRNE5A (#/yr)	PRNR5A (#/yr)	PRNR11A (#/yr)	PRELA2 (#/yr)	PRER12A1 (#/yr)	PRER12A2 (#/yr)
Nonpoint Sources	**Agriculture**	4.81E+14	8.83E+12	3.72E+14	7.33E+09	5.94E+13	1.41E+13	2.10E+15	1.16E+15	7.17E+13	1.39E+16	5.92E+15
	Barren	1.85E+09	2.25E+08	1.15E+07	1.01E+06	2.98E+09	3.26E+08	9.69E+06	1.11E+09	4.22E+08	6.03E+08	1.42E+08
	Forest	1.31E+12	1.23E+12	2.16E+12	3.38E+09	9.84E+12	1.20E+12	6.21E+12	5.85E+11	3.85E+11	3.95E+12	3.31E+12
	Pasture	1.65E+16	4.53E+15	8.89E+14	7.25E+12	4.23E+16	6.25E+15	4.17E+15	8.20E+13	8.22E+13	2.03E+14	2.25E+14
	Septics	6.28E+14	5.36E+13	7.71E+13	2.25E+13	9.18E+14	1.09E+14	6.00E+13	1.28E+14	8.15E+13	1.31E+14	2.04E+14
	Urban High Density	7.90E+09	6.41E+09	4.21E+05	4.92E+04	9.78E+10	1.32E+10	1.18E+09	1.88E+12	0.00E+00	5.00E+11	1.03E+09
	Urban Low Density	3.26E+11	2.20E+11	2.20E+11	3.53E+10	1.30E+12	3.30E+11	4.74E+11	2.66E+11	1.06E+11	1.77E+11	5.81E+12
	Wetland	1.26E+10	0.00E+00	0.00E+00	0.00E+00	5.42E+10	2.94E+09	0.00E+00	8.04E+09	0.00E+00	7.79E+09	0.00E+00
Permitted Point Sources	**NPDES**	5.49E+12	6.91E+09	4.19E+12		1.77E+11					6.55E+12	5.53E+12
	Urban MS4	7.21E+12	2.72E+11	9.94E+11	1.42E+11	1.30E+13	1.40E+12	4.80E+11	3.79E+14	1.45E+13	1.32E+14	1.52E+13
Total Baseline Load		1.76E+16	4.59E+15	1.35E+15	2.99E+13	4.33E+16	6.38E+15	6.34E+15	1.76E+15	2.50E+14	1.44E+16	6.38E+15
Source		PRER12B (#/yr)	PRER12C (#/yr)	PREE13A1 (#/yr)	PREE13A2 (#/yr)	PRER14A1 (#/yr)	PRER14B (#/yr)	PRER14C (#/yr)	PREQ14D (#/yr)	PREQ14E (#/yr)	PREE15A (#/yr)	PREE16A (#/yr)
Nonpoint Sources	**Agriculture**	9.24E+15	3.21E+15	6.83E+12	1.44E+14	4.37E+13	8.55E+14	4.42E+14	3.60E+14	2.64E+14	1.80E+14	2.30E+14
	Barren	9.37E+08	1.34E+08	2.08E+10	4.81E+10	1.95E+10	3.70E+09	9.16E+08	2.67E+09	8.48E+09	2.25E+09	8.14E+09
	Forest	3.50E+12	7.73E+11	2.11E+11	4.76E+11	4.05E+11	1.66E+12	1.02E+12	4.55E+11	6.28E+11	1.96E+11	8.01E+12
	Pasture	1.72E+14	5.44E+13	4.08E+14	6.12E+14	8.47E+14	6.77E+14	1.14E+15	5.88E+14	7.48E+14	4.39E+14	8.16E+14
	Septics	1.91E+14	3.24E+13	7.8472E+13	2.15E+14	1.46E+14	1.60E+14	1.15E+14	5.75E+13	1.67E+14	4.10E+13	1.15E+14
	Urban High Density	3.57E+11	9.60E+10	2.38E+15	2.28E+15	2.56E+15	7.75E+14	1.51E+14	8.22E+12	2.48E+10	1.42E+14	6.47E+14
	Urban Low Density	2.81E+11	2.16E+11	0.00E+00	1.92E+12	7.64E+12	3.86E+13	4.65E+12	1.22E+13	1.28E+13	6.04E+11	3.54E+13
	Wetland	0.00E+00	0.00E+00	1.01E+11	2.11E+10	5.65E+09	2.32E+08	8.14E+08	2.91E+08	0.00E+00	5.81E+07	2.91E+08
Permitted Point Sources	**NPDES**						2.96E+11			1.66E+11		2.79E+11
	Urban MS4	1.77E+14	4.86E+13	1.77E+17	3.65E+17	7.21E+16	2.48E+15	1.78E+16	2.25E+15	1.41E+15	8.60E+15	6.69E+15
Total Baseline Load		9.78E+15	3.34E+15	1.80E+17	3.68E+17	7.57E+16	-	1.96E+16	3.28E+15	2.61E+15	9.40E+15	8.55E+15

Source		PREE17A (#/yr)	UCW--25 (#/yr)	UCW--32 (#/yr)	UCW--33 (#/yr)	UCW--40 (#/yr)	PREE33A (#/yr)	PREE34A (#/yr)	PREE35A (#/yr)	PREK35.1 (#/yr)	PRER37A (#/yr)	UCW--13 (#/yr)	UCW--10 (#/yr)
Nonpoint Sources	**Agriculture**	3.53E+14	5.90E+13	1.79E+13	3.40E+12	0.00E+00	3.52E+14	3.74E+13	1.37E+15	2.83E+14	3.19E+14	0.00E+00	2.94E+13
	Barren	1.13E+10	4.52E+10	2.57E+10	1.80E+10	5.28E+07	2.95E+10	3.05E+10	1.16E+10	7.90E+09	6.17E+09	1.32E+09	3.69E+07
	Forest	9.93E+12	1.97E+12	3.05E+11	9.87E+10	2.18E+09	1.31E+12	7.87E+10	3.03E+12	4.49E+11	1.53E+12	8.58E+09	6.34E+10
	Pasture	2.81E+15	3.10E+15	3.34E+14	2.44E+14	7.74E+12	1.91E+15	5.73E+14	3.12E+15	6.49E+14	7.59E+14	4.27E+13	7.45E+14
	Septics	6.28E+13	1.85E+14	4.75E+13	2.44E+13	7.97E+12	1.90E+14	5.03E+13	2.43E+14	6.10E+13	1.78E+14	1.25E+13	2.36E+13
	Urban High Density	7.69E+15	1.29E+16	1.82E+15	1.01E+14	5.49E+14	9.94E+14	0.00E+00	1.69E+15	6.79E+15	2.72E+14	0.00E+00	3.28E+10
	Urban Low Density	4.22E+13	2.99E+13	4.95E+12	9.07E+11	9.49E+10	1.45E+13	5.33E+11	4.46E+13	8.57E+12	1.02E+13	4.15E+10	2.99E+10
	Wetland	5.75E+08	3.84E+11	2.21E+09	5.61E+08	0.00E+00	1.50E+08	0.00E+00	6.99E+09	5.61E+08	4.49E+08	0.00E+00	6.99E+10
Permitted Point Sources	**NPDES**		9.05E+13				9.39E+11		4.48E+11	4.16E+13	2.76E+12		
	Urban MS4	1.89E+15	1.40E+17	3.19E+15	4.72E+15	2.47E+16	6.53E+16	1.33E+16	8.05E+15	1.21E+16	8.58E+15	8.08E+15	1.72E+10
Total Baseline Load		1.29E+16	1.56E+17	5.41E+15	5.10E+15	2.53E+16	6.88E+16	1.39E+16	1.45E+16	1.99E+16	1.01E+16	8.13E+15	7.98E+14

Source		PRSE53A (#/yr)	PRSR54A--1 (#/yr)	PRSR54A--2 (#/yr)	PRSR54A--3 (#/yr)	PRSR54A--4 (#/yr)	PRSE60A (#/yr)	PRSL160A (#/yr)	PRSL260A (#/yr)	PRSR61A (#/yr)	PRSE61A (#/yr)	PRSR67A (#/yr)	UCW--39 (#/yr)
Nonpoint Sources	**Agriculture**	6.20E+13	4.32E+13	1.59E+13	1.17E+14	1.70E+14	2.54E+14	2.14E+15	2.63E+15	2.47E+15	1.88E+15	1.34E+15	2.25E+14
	Barren	4.39E+07	9.05E+07	6.54E+07	2.64E+07	3.88E+07	3.72E+08	7.76E+08	6.13E+08	3.76E+08	4.87E+08	1.10E+08	4.33E+07
	Forest	2.95E+11	8.98E+11	1.13E+12	1.21E+12	2.28E+12	1.13E+12	5.78E+12	1.16E+13	1.24E+13	1.91E+13	6.09E+12	2.63E+11
	Pasture	1.38E+15	2.38E+15	9.15E+14	3.28E+14	9.46E+14	8.66E+14	5.33E+15	9.11E+15	2.62E+15	2.43E+15	2.34E+15	5.78E+13
	Septics	5.22E+13	9.66E+13	7.86E+13	4.92E+13	6.77E+13	1.41E+14	1.93E+14	1.63E+14	1.07E+14	1.61E+14	1.84E+14	2.46E+13
	Urban High Density	3.62E+10	1.67E+11	3.11E+10	0.00E+00	1.43E+10	1.13E+10	1.50E+09	4.12E+10	0.00E+00	7.43E+09	1.25E+10	4.63E+09
	Urban Low Density	1.13E+11	1.58E+11	1.21E+11	2.65E+10	1.08E+11	6.99E+10	1.20E+11	5.46E+11	1.90E+11	1.95E+11	1.38E+11	1.82E+09
	Wetland	3.08E+10	4.53E+10	0.00E+00	0.00E+00	0.00E+00	1.57E+09	1.09E+10	0.00E+00	0.00E+00	4.04E+10	6.01E+10	2.56E+10
Permitted Point Sources	**NPDES**										1.19E+11	1.91E+12	
	Urban MS4	1.10E+11		1.77E+10	1.74E+09	1.04E+11	5.15E+11	8.92E+11	1.44E+11	9.66E+10	4.90E+11	5.12E+11	
Total Baseline Load		1.50E+15	2.52E+15	1.01E+15	4.95E+14	1.19E+15	1.26E+15	7.67E+15	1.19E+16	5.21E+15	4.49E+15	3.88E+15	3.08E+14

Source		PRSR68A	PRSL68A	PRSE69A	PRSR69A1	UVL-E	UVL-W	PRSL69A	UCW--7	UCW--35	PRWR77A	PRWR77B	PRWR77C
		(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)
Nonpoint Sources	**Agriculture**	2.27E+15	3.70E+15	5.21E+12	3.14E+13	4.94E+13	1.49E+10	9.11E+12	2.86E+15	0.00E+00	3.86E+12	9.91E+11	3.34E+13
	Barren	2.53E+08	9.93E+07	2.62E+06	2.95E+07	3.56E+07	9.06E+07	1.55E+07	2.87E+08	1.52E+09	1.90E+08	2.79E+07	1.74E+07
	Forest	6.36E+12	6.96E+12	2.34E+11	6.36E+11	2.46E+12	8.05E+11	1.43E+12	3.27E+11	2.28E+12	3.18E+12	5.87E+11	3.11E+12
	Pasture	2.17E+15	2.36E+15	6.20E+12	2.59E+13	4.26E+14	2.03E+14	1.80E+13	1.09E+15	5.87E+14	3.18E+14	2.64E+13	3.93E+13
	Septics	2.24E+14	1.37E+14	2.77E+13	7.59E+13	3.34E+14	1.41E+14	6.65E+13	9.27E+13	7.16E+13	2.03E+14	3.59E+13	1.27E+14
	Urban High Density	3.76E+09	0.00E+00	1.31E+10	9.67E+08	1.44E+11	6.37E+10	1.24E+09	4.61E+11	1.04E+11	6.27E+10	1.69E+10	1.12E+10
	Urban Low Density	1.00E+11	1.71E+11	1.04E+10	4.13E+10	2.20E+11	8.04E+10	5.11E+10	1.18E+11	4.37E+10	1.48E+11	7.91E+09	1.60E+11
	Wetland	1.74E+09	0.00E+00	3.28E+09	2.51E+08	4.58E+10	2.00E+11	0.00E+00	5.22E+11	3.25E+11	1.69E+10	0.00E+00	0.00E+00
Permitted Point Sources	**NPDES**	5.71E+13				3.32E+12					2.49E+13		1.14E+13
	Urban MS4	9.04E+11	1.20E+10	1.93E+11	5.97E+11	1.24E+12	3.20E+11	1.00E+11	5.68E+10	5.44E+11	2.64E+12	6.50E+11	1.93E+11
Total Baseline Load		4.72E+15	6.20E+15	3.96E+13	1.34E+14	8.17E+14	3.45E+14	9.52E+13	4.05E+15	6.62E+14	-	6.45E+13	2.15E+14

Source		PRWR77D	PRWR77E	PRWR77F	PRWR77G	PRWR77H	PRWR77I	URGL
		(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)
Nonpoint Sources	**Agriculture**	0.00E+00	5.47E+13	3.32E+12	1.66E+12	1.47E+13	1.47E+13	1.71E+12
	Barren	5.69E+07	5.10E+07	8.00E+07	3.38E+07	2.58E+07	1.12E+08	1.23E+10
	Forest	1.01E+12	1.24E+13	8.12E+12	4.41E+12	4.06E+12	3.00E+12	6.79E+10
	Pasture	1.55E+14	2.13E+14	1.80E+14	9.52E+13	4.45E+13	3.17E+13	5.91E+14
	Septics	1.41E+14	8.78E+13	5.19E+13	2.71E+13	4.22E+13	5.43E+13	6.84E+13
	Urban High Density	6.04E+10	0.00E+00	7.88E+07	0.00E+00	7.01E+08	1.60E+09	1.71E+15
	Urban Low Density	8.15E+10	3.03E+11	9.28E+10	5.99E+10	8.35E+10	1.02E+11	1.04E+13
	Wetland	1.47E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.49E+10
Permitted Point Sources	**NPDES**			8.57E+10		5.97E+10		
	Urban MS4	1.18E+12	4.15E+11	4.77E+11	1.16E+11	3.10E+11	2.25E+11	3.70E+16
Total Baseline Load		2.99E+14	3.69E+14	2.44E+14	1.29E+14	1.06E+14	1.04E+14	3.94E+16

Table 5-2. TMDL summary by assessment unit

Source		UNC--3	PRNL3A1	PRNR3A2	PRNQ3B	UNC--2	PRNE5A	PRNR5A	PRNR11A	PRELA2	PRER12A1	PRER12A2
		(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)
LA	**Agriculture**	1.19E+14	6.42E+10	1.86E+14	1.88E+09	5.34E+13	1.31E+09	1.16E+15	3.19E+14	6.45E+09	1.49E+15	4.35E+14
	Barren	5.88E+08	5.31E+06	5.22E+05	2.58E+05	2.69E+09	2.95E+04	1.03E+06	4.18E+08	8.14E+07	1.50E+07	3.79E+07
	Forest	8.75E+11	5.93E+10	1.89E+12	8.68E+08	8.85E+12	1.08E+10	3.29E+12	1.95E+11	2.01E+11	5.00E+11	1.02E+12
	Pasture	6.53E+15	3.25E+14	3.71E+14	1.86E+12	3.81E+16	5.73E+11	1.11E+15	2.70E+13	3.00E+13	2.01E+13	8.07E+13
	Septics[1]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Urban High Density	6.11E+09	7.80E+05	2.60E+02	1.26E+04	8.81E+10	1.19E+06	7.94E+08	3.81E+11	0.00E+00	7.29E+09	6.96E+08
	Urban Low Density	1.48E+11	1.66E+10	7.18E+10	9.08E+09	1.17E+12	3.02E+07	1.97E+11	6.88E+10	7.15E+10	2.59E+07	1.67E+12
	Wetland	1.13E+10	0.00E+00	0.00E+00	0.00E+00	4.88E+10	2.64E+07	0.00E+00	7.24E+07	0.00E+00	7.01E+07	0.00E+00
WLA	**NPDES**[2]	5.49E+12	6.91E+09	4.19E+12		1.77E+11					6.55E+12	5.53E+11
	Urban MS4	3.45E+12	1.00E+10	2.67E+11	3.65E+10	1.17E+13	1.27E+08	1.06E+11	1.54E+14	3.46E+12	6.21E+12	4.76E+12
MOS	**Margin of Safety**[3]	7.40E+14	3.61E+13	6.27E+13	2.12E+11	4.24E+15	6.50E+10	2.53E+14	5.56E+13	3.75E+12	1.69E+14	5.82E+13
TMDL	**Total Maximum Daily Load**	7.40E+15	3.61E+14	6.27E+14	2.12E+12	4.24E+16	6.50E+11	2.53E+15	5.56E+14	3.75E+13	1.69E+15	5.82E+14
Source		PRER12B	PRER12C	PREE13A1	PREE13A2	PRER14A1	PRER14B	PRER14C	PREQ14D	PREQ14E	PREE15A	PREE16A
		(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)	(#/yr)
LA	**Agriculture**	1.75E+15	1.04E+15	6.15E+12	3.14E+13	2.31E+11	3.92E+13	3.65E+13	3.21E+13	2.73E+13	5.02E+12	6.07E+13
	Barren	2.42E+08	2.83E+07	1.88E+10	1.09E+09	2.79E+07	6.85E+07	7.62E+07	6.70E+07	6.55E+07	4.70E+07	3.49E+09
	Forest	1.21E+12	3.62E+11	1.90E+11	1.49E+11	8.93E+10	1.21E+12	6.28E+11	1.75E+11	3.70E+11	4.56E+09	7.01E+12
	Pasture	4.73E+13	1.72E+13	3.67E+14	4.86E+13	2.12E+12	1.85E+13	8.57E+13	6.13E+13	6.76E+13	6.34E+12	1.88E+14
	Septics[1]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Urban High Density	1.80E+11	1.49E+10	2.14E+15	1.58E+12	8.13E+12	3.26E+12	1.83E+11	9.43E+11	3.97E+08	4.32E+11	1.38E+13
	Urban Low Density	2.50E+10	8.77E+10	0.00E+00	1.81E+11	3.08E+10	2.10E+12	3.93E+11	2.90E+12	2.12E+12	1.41E+10	9.68E+12
	Wetland	0.00E+00	0.00E+00	9.13E+10	1.90E+08	5.09E+07	2.09E+06	7.32E+06	2.62E+06	0.00E+00	5.23E+05	2.22E+07
WLA	**NPDES**[2]						4.77E+12			1.66E+10		2.79E+11
	Urban MS4	7.22E+13	1.63E+13	1.60E+17	1.80E+14	1.09E+14	1.72E+13	3.90E+13	1.06E+13	1.85E+13	2.61E+13	5.56E+13
MOS	**Margin of Safety**[3]	2.08E+14	1.20E+14	1.80E+16	2.92E+13	1.33E+13	9.58E+12	1.80E+13	1.20E+13	1.29E+13	4.22E+12	3.72E+13
TMDL	**Total Maximum Daily Load**	2.08E+15	1.20E+15	1.80E+17	2.92E+14	1.33E+14	9.58E+13	1.80E+14	1.20E+14	1.29E+14	4.22E+13	3.72E+14

Source		PREE17A (#/yr)	UCW--25 (#/yr)	UCW--32 (#/yr)	UCW--33 (#/yr)	UCW--40 (#/yr)	PREE33A (#/yr)	PREE34A (#/yr)	PREE35A (#/yr)	PREK35.1 (#/yr)	PRER37A (#/yr)	UCW--13 (#/yr)	UCW--10 (#/yr)
LA	Agriculture	1.63E+13	1.69E+13	2.20E+12	6.46E+11	0.00E+00	2.33E+13	1.04E+11	8.71E+13	4.74E+11	1.94E+13	0.00E+00	2.61E+13
	Barren	3.44E+08	1.97E+10	2.16E+10	1.38E+10	4.75E+07	2.03E+09	8.44E+07	5.30E+08	3.77E+06	1.30E+08	7.68E+05	2.53E+07
	Forest	8.57E+12	6.15E+11	2.38E+11	6.22E+10	1.96E+09	1.02E+12	7.08E+10	1.95E+12	4.36E+10	1.05E+12	7.72E+09	5.70E+10
	Pasture	1.34E+14	8.27E+14	2.09E+14	7.71E+13	6.96E+12	1.10E+14	1.59E+12	2.81E+14	8.26E+11	3.75E+13	2.44E+12	5.87E+14
	Septics[1]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Urban High Density	7.61E+13	5.59E+15	1.61E+15	8.13E+13	4.94E+14	2.01E+11	0.00E+00	1.05E+13	8.17E+12	9.01E+12	0.00E+00	2.77E+10
	Urban Low Density	2.50E+12	4.14E+12	3.35E+12	5.05E+11	8.54E+10	1.34E+12	1.47E+09	5.31E+12	2.28E+10	9.36E+11	8.96E+09	2.14E+10
	Wetland	5.18E+08	3.00E+11	1.99E+09	2.39E+08	0.00E+00	1.35E+08	0.00E+00	5.29E+08	5.05E+06	4.04E+06	0.00E+00	6.29E+10
WLA	NPDES[2]		1.09E+13				9.39E+11		4.14E+11	4.28E+12	2.76E+12		
	Urban MS4	1.61E+13	7.15E+16	2.43E+15	3.80E+15	2.22E+16	1.25E+14	3.67E+13	8.33E+13	1.29E+13	6.20E+13	4.75E+12	1.54E+10
MOS	Margin of Safety[3]	2.82E+13	8.66E+15	4.73E+14	4.40E+14	2.53E+15	2.91E+13	4.28E+12	5.22E+13	2.97E+12	1.47E+13	8.01E+11	6.81E+13
TMDL	Total Maximum Daily Load	2.82E+14	8.66E+16	4.73E+15	4.40E+15	2.53E+16	2.91E+14	4.28E+13	5.22E+14	2.97E+13	1.47E+14	8.01E+12	6.81E+14
Source		PRSE53A (#/yr)	PRSR54A--1 (#/yr)	PRSR54A--2 (#/yr)	PRSR54A--3 (#/yr)	PRSR54A--4 (#/yr)	PRSE60A (#/yr)	PRSL160A (#/yr)	PRSL260A (#/yr)	PRSR61A (#/yr)	PRSE61A (#/yr)	PRSR67A (#/yr)	UCW--39 (#/yr)
LA	Agriculture	1.11E+11	2.26E+13	6.29E+12	6.88E+13	1.15E+14	2.60E+12	1.44E+15	1.07E+15	4.05E+14	5.36E+14	4.28E+14	1.25E+14
	Barren	1.06E+07	3.22E+07	7.40E+06	1.65E+07	2.61E+07	5.54E+07	5.25E+08	3.27E+08	5.66E+07	1.30E+08	5.42E+07	3.30E+07
	Forest	1.79E+11	6.61E+11	4.16E+11	7.41E+11	1.93E+12	1.79E+11	5.20E+12	5.64E+12	1.96E+12	6.71E+12	1.99E+12	1.39E+11
	Pasture	4.77E+14	1.00E+15	1.36E+14	1.70E+14	5.88E+14	1.56E+14	3.63E+15	4.99E+15	4.03E+14	5.41E+14	5.89E+14	3.23E+13
	Septics[1]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Urban High Density	8.89E+09	9.89E+09	1.69E+08	0.00E+00	9.67E+09	1.49E+09	1.03E+09	1.76E+10	0.00E+00	4.39E+09	9.89E+08	4.06E+09
	Urban Low Density	3.90E+10	3.95E+10	9.93E+09	1.62E+10	6.55E+10	1.13E+10	8.09E+10	3.16E+11	2.46E+10	3.60E+10	5.35E+10	1.34E+09
	Wetland	6.82E+09	6.62E+09	0.00E+00	0.00E+00	0.00E+00	1.41E+07	9.84E+09	0.00E+00	0.00E+00	2.31E+09	3.99E+09	1.61E+10
WLA	NPDES[2]										1.19E+11	1.91E+12	
	Urban MS4	3.02E+09		5.00E+07	6.43E+08	7.03E+10	2.50E+10	6.20E+11	8.45E+10	1.92E+08	1.32E+11	1.61E+11	
MOS	Margin of Safety[3]	5.30E+13	1.14E+14	1.58E+13	2.66E+13	7.84E+13	1.77E+13	5.64E+14	6.75E+14	9.00E+13	1.20E+14	1.13E+14	1.75E+13
TMDL	Total Maximum Daily Load	5.30E+14	1.14E+15	1.58E+14	2.66E+14	7.84E+14	1.77E+14	5.64E+15	6.75E+15	9.00E+14	1.20E+15	1.13E+15	1.75E+14

Source		PRSR68A (#/yr)	PRSL68A (#/yr)	PRSE69A (#/yr)	PRSR69A1 (#/yr)	UVL-E (#/yr)	UVL-W (#/yr)	PRSL69A (#/yr)	UCW--7 (#/yr)	UCW--35 (#/yr)	PRWR77A (#/yr)	PRWR77B (#/yr)	PRWR77C (#/yr)
LA	**Agriculture**	7.49E+14	3.33E+15	2.45E+12	1.82E+13	3.91E+13	1.34E+10	6.15E+12	1.39E+15	0.00E+00	2.61E+12	6.69E+11	7.21E+12
	Barren	5.18E+07	8.94E+07	1.21E+06	1.82E+07	8.16E+06	6.25E+07	1.06E+07	2.28E+08	1.02E+09	8.00E+07	1.88E+07	8.39E+06
	Forest	4.42E+12	6.26E+12	2.11E+11	5.73E+11	2.09E+12	7.25E+11	1.28E+12	2.94E+11	2.05E+12	2.86E+12	5.28E+11	2.80E+12
	Pasture	7.79E+14	2.12E+15	3.54E+12	1.67E+13	2.76E+14	1.31E+14	1.30E+13	6.67E+14	2.77E+14	1.35E+14	1.78E+13	1.04E+13
	Septics[1]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Urban High Density	2.31E+08	0.00E+00	6.02E+09	5.75E+08	1.16E+11	5.74E+10	8.35E+08	3.67E+11	3.05E+10	2.21E+10	1.14E+10	2.70E+09
	Urban Low Density	4.76E+10	1.54E+11	5.34E+09	2.76E+10	1.33E+11	7.23E+10	3.81E+10	6.84E+10	2.00E+10	6.26E+10	5.34E+09	2.52E+10
	Wetland	6.99E+08	0.00E+00	2.95E+09	2.26E+08	4.12E+10	1.80E+11	0.00E+00	4.70E+11	2.93E+11	1.52E+10	0.00E+00	0.00E+00
WLA	**NPDES[2]**	5.71E+12				3.32E+12					2.55E+13		1.14E+12
	Urban MS4	6.11E+10	1.08E+10	8.93E+10	3.80E+11	3.15E+11	1.11E+11	7.10E+10	5.11E+10	4.00E+11	1.05E+12	4.39E+11	6.85E+10
MOS	**Margin of Safety[3]**	1.71E+14	6.07E+14	7.01E+11	3.99E+12	3.57E+13	1.46E+13	2.28E+12	2.28E+14	3.11E+13	1.86E+13	2.16E+12	2.41E+12
TMDL	**Total Maximum Daily Load**	1.71E+15	6.07E+15	7.01E+12	3.99E+13	3.57E+14	1.46E+14	2.28E+13	2.28E+15	3.11E+14	1.86E+14	2.16E+13	2.41E+13

Source		PRWR77D (#/yr)	PRWR77E (#/yr)	PRWR77F (#/yr)	PRWR77G (#/yr)	PRWR77H (#/yr)	PRWR77I (#/yr)	URGL (#/yr)
LA	**Agriculture**	0.00E+00	3.69E+13	2.24E+12	1.12E+12	6.08E+12	9.89E+12	1.54E+08
	Barren	3.84E+07	3.44E+07	5.29E+07	2.28E+07	7.14E+06	7.55E+07	1.11E+06
	Forest	9.06E+11	1.12E+13	7.31E+12	3.97E+12	3.66E+12	2.70E+12	6.11E+08
	Pasture	1.05E+14	1.44E+14	8.41E+13	6.42E+13	1.33E+13	2.08E+13	5.32E+10
	Septics[1]	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Urban High Density	4.08E+10	0.00E+00	6.28E+06	0.00E+00	4.48E+07	7.96E+08	1.53E+11
	Urban Low Density	5.50E+10	2.04E+11	5.18E+10	4.04E+10	3.14E+10	6.84E+10	9.36E+08
	Wetland	1.33E+11	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.14E+08
WLA	**NPDES[2]**			8.57E+10		5.97E+10		
	Urban MS4	7.97E+11	2.80E+11	1.98E+11	7.84E+10	1.23E+11	1.27E+11	3.33E+12
MOS	**Margin of Safety[3]**	1.19E+13	2.14E+13	1.04E+13	7.72E+12	2.59E+12	3.73E+12	3.93E+11
TMDL	**Total Maximum Daily Load**	1.19E+14	2.14E+14	1.04E+14	7.72E+13	2.59E+13	3.73E+13	3.93E+12

[1]Based on a 100% reduction in bacteria loading from failing septic systems.

[2]Based on a reduction in facility permit limits to 200 colonies/100 mL, or ambient water quality standards.

[3]A set-aside 10% explicit MOS was taken.

[4]The individual WLAs are found in Tables 5-3 and 5-4.

5.4 Load Allocations

The LA is the portion in the TMDL that is assigned to nonpoint sources. Tables 5-1 and 5-2 show the total loads by land use type and assessment unit. These loads are inclusive of MS4 loads. For this TMDL, the MS4 bacteria loads were subtracted from the modeled urban loads' LA, and reallocated as WLAs. The remaining LAs are presented in Tables 5-1 and 5-2. For additional information regarding MS4 loads, see the next section.

On the basis of the analysis performed, the primary nonpoint source contributions to the study area are from the land surface. Source-based reductions were arrived at through an iterative process of examining bacteria reduction possibilities by varying bacteria loads from each source to the system and ensuring that the TMDL target was met. Specifically, nonpoint source loads were reduced by assessment unit until fecal coliform bacteria concentrations in that segment met the TMDL targets described in Section 5.3.

LAs were performed using a *top-down* reduction methodology. This methodology entails applying reductions to headwaters first, until waters in these subwatersheds meet the TMDL target. This method has the effect of also reducing in-stream concentrations in downstream subwatersheds by discharging waters of higher quality to subsequent reaches in the simulated network. These waters then serve to dilute fecal coliform bacteria loads that enter downstream.

However, this methodology sometimes requires large reductions in headwater subbasins. This occurs when significant sources of a pollutant exist in that watershed and diluting flows from upstream reaches are not available. Larger reductions are required in these watersheds to meet the TMDL target. Large reductions in excess of 90 percent are sometimes required in areas where excessive in-stream pollutant concentrations have been observed.

For example, Figures 4-7 and 4-8 show a water quality calibration where in-stream measurements in excess of 20,000 colonies/100 mL have been observed. The geometric mean water quality standard for fecal coliform bacteria is 200 colonies/100 mL, so a simplistic reduction from 20,000 colonies to 200 colonies would require a 99 percent reduction. This example is presented to provide the magnitude of the impairment and justify the reductions shown in Tables 5-1 and 5-2.

The LAs are separated by land use and separated from septic loads, which are also considered a component of the LA.

5.5 Wasteload Allocations

Federal regulations (40 CFR 130.7) require TMDLs to include individual WLAs for each point source. In addition, EPA's stormwater permitting regulations require municipalities to obtain permit coverage for all stormwater discharges from urban MS4s. A November 22, 2002, EPA Memorandum from Robert Wayland and James Hanlon, Water Division Directors (http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/upload/finalwwtmdl.pdf) clarified existing regulatory requirements for MS4s connected with TMDLs. The key points are the following:

- NPDES-regulated MS4 discharges must be included in the WLA of the TMDL and may not be addressed by the LA component of TMDL.
- The stormwater allotment can be a gross allotment and does not need to be apportioned to specific outfalls.
- Industrial stormwater permits need to reflect technology-based and water quality based requirements.

In accordance with this memorandum, MS4s were treated as point sources for TMDL and NPDES permitting purposes, and the bacteria loading generated within the boundary of an MS4 area was assigned a WLA in addition to the WLA for the point source dischargers. There are also four point source facilities with four outfalls, and one MS4 community in the study area, all requiring WLAs. The components of the WLA are summarized below.

WLA: MS4 Municipalities

Stormwater bacteria loads are covered under the Phase II NPDES Stormwater Program and were considered wasteloads at this time. Runoff from residential areas and UAs during storm events can be a significant fecal coliform bacteria source, delivering bacteria to the waterbody. EPA's stormwater permitting regulations require public entities to obtain NPDES permit coverage for stormwater discharges from MS4s in specified UAs. Table 5-3 presents a summary of the MS4 components, which required a 73 percent reduction of bacteria loading overall. The baseline MS4 loads were caculated based on loading rates presented in Table 2-3, which were reduced during the allocation runs to derive the WLA for the same municipalities in Table 5-3. Although there is one census UA covered under MS4, it overlaps with both assessment units and counties; hence, there are 190 total MS4 components.

WLA: Permitted Facilities

For the permitted facilities, the fecal coliform bacteria WLAs were calculated using a concentration of 200 colonies/100 mL and the facilities' current permitted flow. Table 5-4 presents the baseline load, WLAs, and the percent reductions required to meet the TMDL targets. The baseline load is calculated using the facilities' current permitted flow and concentration. The WLA was calculated after reducing bacteria loads during the allocation process. Specifically, permitted facilities with allowable discharge concentrations greater than 200 CFU/100mL were reduced to that level during the allocation process so that discharges from these facilities do not exceed the ambient water quality standard. This reduced the bacteria loads from permitted facilities by 66 percent overall. The WLA is equal to the allocation scenario concentration multiplied by the permitted flow.

Table 5-3. Bacteria loads for the MS4 component of the WLA

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)	WLA FC (#/yr)	Reduction (%)
San Juan, PR	Bayamon	79093	PREE13A1	2.8232E+16	2.5409E+16	10.00%
San Juan, PR	Catano	79093	PREE13A1	8.0042E+16	7.2038E+16	10.00%
San Juan, PR	Guaynabo	79093	PREE13A1	4.5997E+16	4.1397E+16	10.00%
San Juan, PR	San Juan	79093	PREE13A1	1.6105E+16	1.4494E+16	10.00%
San Juan, PR	Toa Baja	79093	PREE13A1	6.9348E+15	6.2413E+15	10.00%
San Juan, PR	Guaynabo	79093	PREE13A2	4.6804E+16	2.0486E+13	99.96%
San Juan, PR	San Juan	79093	PREE13A2	3.0620E+17	1.4956E+14	99.95%
San Juan, PR	Trujillo Alto	79093	PREE13A2	1.1934E+16	1.0420E+13	99.91%
San Juan, PR	Canovanas	79093	PREE15A	5.4164E+14	1.1408E+13	97.89%
San Juan, PR	Loiza	79093	PREE15A	2.9216E+14	2.5502E+11	99.91%
San Juan, PR	Rio Grande	79093	PREE15A	7.7682E+15	1.4480E+13	99.81%
San Juan, PR	Rio Grande	79093	PREE16A	6.6943E+15	5.5567E+13	99.17%
Fajardo, PR	Luquillo	28981	PREE17A	5.7913E+13	3.1845E+12	94.50%
San Juan, PR	Rio Grande	79093	PREE17A	1.8355E+15	1.2928E+13	99.30%
San Juan, PR	Humacao	79093	PREE33A	6.5159E+16	1.1569E+14	99.82%
San Juan, PR	Las Piedras	79093	PREE33A	1.6633E+14	9.0170E+12	94.58%
San Juan, PR	Yabucoa	79093	PREE33A	2.1935E+11	9.9357E+09	95.47%
San Juan, PR	Humacao	79093	PREE34A	1.3271E+16	3.6738E+13	99.72%
San Juan, PR	Yabucoa	79093	PREE34A	7.0919E+11	1.9633E+09	99.72%
San Juan, PR	Humacao	79093	PREE35A	1.7927E+11	2.3402E+10	86.95%
San Juan, PR	Las Piedras	79093	PREE35A	2.3727E+10	6.1082E+09	74.26%
San Juan, PR	San Lorenzo	79093	PREE35A	2.6982E+11	3.9270E+10	85.45%
San Juan, PR	Yabucoa	79093	PREE35A	8.0495E+15	8.3208E+13	98.97%
San Juan, PR	Maunabo	79093	PREK35.1	5.2728E+09	9.6381E+06	99.82%
San Juan, PR	Yabucoa	79093	PREK35.1	1.2082E+16	1.2908E+13	99.89%
San Juan, PR	Aguas Buenas	79093	PRELA2	8.3086E+08	7.4778E+04	99.99%
San Juan, PR	Caguas	79093	PRELA2	4.2499E+11	3.8249E+07	99.99%
San Juan, PR	Cidra	79093	PRELA2	1.4106E+13	3.4555E+12	75.50%
San Juan, PR	Carolina	79093	PREQ14D	2.2436E+15	8.5809E+12	99.62%
San Juan, PR	Gurabo	79093	PREQ14D	1.7983E+11	4.3578E+10	75.77%
San Juan, PR	Trujillo Alto	79093	PREQ14D	6.8905E+12	1.9797E+12	71.27%
San Juan, PR	Carolina	79093	PREQ14E	7.2365E+10	1.1588E+09	98.40%
San Juan, PR	Gurabo	79093	PREQ14E	1.1827E+13	1.7329E+12	85.35%
San Juan, PR	Trujillo Alto	79093	PREQ14E	1.4006E+15	1.6793E+13	98.80%
San Juan, PR	Bayamon	79093	PRER12A1	9.6220E+13	6.2091E+12	93.55%
San Juan, PR	Catano	79093	PRER12A1	2.5933E+10	2.3340E+06	99.99%
San Juan, PR	Guaynabo	79093	PRER12A1	3.5949E+13	5.4015E+09	99.98%
San Juan, PR	Toa Baja	79093	PRER12A1	1.0170E+10	9.1526E+05	99.99%
San Juan, PR	Aguas Buenas	79093	PRER12A2	1.1612E+13	3.9104E+12	66.32%
San Juan, PR	Bayamon	79093	PRER12A2	1.1112E+12	1.0001E+08	99.99%
San Juan, PR	Cidra	79093	PRER12A2	1.7954E+12	7.9843E+11	55.53%
San Juan, PR	Comerio	79093	PRER12A2	2.7465E+10	1.8539E+10	32.50%
San Juan, PR	Guaynabo	79093	PRER12A2	6.4406E+11	2.8350E+10	95.60%
San Juan, PR	Aguas Buenas	79093	PRER12B	2.4008E+12	3.6641E+11	84.74%
San Juan, PR	Bayamon	79093	PRER12B	1.2134E+10	1.0920E+06	99.99%

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)	WLA FC (#/yr)	Reduction (%)
San Juan, PR	Guaynabo	79093	PRER12B	1.3357E+14	4.6721E+13	65.02%
San Juan, PR	San Juan	79093	PRER12B	4.1195E+13	2.5142E+13	38.97%
San Juan, PR	Bayamon	79093	PRER12C	4.8613E+13	1.6345E+13	66.38%
San Juan, PR	Canovanas	79093	PRER14A1	8.6742E+15	7.8068E+11	99.99%
San Juan, PR	Carolina	79093	PRER14A1	5.0824E+16	4.5742E+12	99.99%
San Juan, PR	San Juan	79093	PRER14A1	4.4657E+13	5.4097E+11	98.79%
San Juan, PR	Trujillo Alto	79093	PRER14A1	1.2562E+16	1.0353E+14	99.18%
San Juan, PR	Canovanas	79093	PRER14B	2.3843E+15	1.5453E+13	99.35%
San Juan, PR	Rio Grande	79093	PRER14B	9.4442E+13	1.7445E+12	98.15%
San Juan, PR	Canovanas	79093	PRER14C	9.3005E+15	1.8380E+13	99.80%
San Juan, PR	Carolina	79093	PRER14C	8.4987E+15	2.0576E+13	99.76%
San Juan, PR	Juncos	79093	PRER14C	1.9585E+10	1.3602E+09	93.05%
San Juan, PR	Maunabo	79093	PRER37A	8.5804E+15	6.1975E+13	99.28%
San Juan, PR	Yabucoa	79093	PRER37A	5.2728E+09	6.9062E+08	86.90%
Aguadilla--Isabela--San Sebastian, PR	Camuy	00631	PRNE5A	1.1076E+11	1.0268E+07	99.99%
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	PRNE5A	3.0662E+09	2.8423E+05	99.99%
Arecibo, PR	Camuy	03034	PRNE5A	4.9926E+11	4.4933E+07	99.99%
Arecibo, PR	Hatillo	03034	PRNE5A	7.8661E+11	7.1360E+07	99.99%
Aguadilla--Isabela--San Sebastian, PR	Isabela	00631	PRNL3A1	3.0474E+09	2.7426E+05	99.99%
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	PRNL3A1	4.8758E+09	8.7822E+08	81.99%
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	PRNL3A1	2.5565E+11	9.1298E+09	96.43%
Arecibo, PR	Camuy	03034	PRNL3A1	1.5899E+08	2.8637E+07	81.99%
Arecibo, PR	Quebradillas	03034	PRNL3A1	8.3471E+09	7.5124E+05	99.99%
Aguadilla--Isabela--San Sebastian, PR	Isabela	00631	PRNQ3B	1.4207E+11	3.6486E+10	74.32%
San Juan, PR	Bayamon	79093	PRNR11A	3.4768E+14	1.4736E+14	57.62%
San Juan, PR	Catano	79093	PRNR11A	2.8269E+12	5.7023E+11	79.83%
San Juan, PR	Toa Alta	79093	PRNR11A	1.7115E+11	9.7524E+10	43.02%
San Juan, PR	Toa Baja	79093	PRNR11A	2.8813E+13	6.0729E+12	78.92%
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	PRNR3A2	8.4670E+11	2.1612E+11	74.47%
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	PRNR3A2	1.4751E+11	5.0915E+10	65.48%
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	PRNR5A	2.9827E+11	9.2799E+10	68.89%
Aguadilla--Isabela--San Sebastian, PR	Utuado	00631	PRNR5A	1.8130E+11	1.2923E+10	92.87%
Guayama, PR	Salinas	35866	PRSE53A	1.1042E+11	3.0192E+09	97.27%
Juana Diaz, PR	Juana Diaz	43453	PRSE60A	4.6902E+11	2.4982E+10	94.67%
Juana Diaz, PR	Villalba	43453	PRSE60A	1.8889E+10	1.0319E+07	99.95%
Ponce, PR	Juana Diaz	70642	PRSE60A	2.3378E+10	2.1040E+06	99.99%
Ponce, PR	Ponce	70642	PRSE60A	3.6862E+09	3.3176E+05	99.99%
Juana Diaz, PR	Juana Diaz	43453	PRSE61A	4.5384E+09	4.0845E+09	10.00%
Ponce, PR	Juana Diaz	70642	PRSE61A	2.1401E+10	1.9261E+10	10.00%
Ponce, PR	Ponce	70642	PRSE61A	4.6400E+11	1.0873E+11	76.57%
Yauco, PR	Guanica	97561	PRSE69A	1.9317E+11	8.9329E+10	53.76%
Juana Diaz, PR	Juana Diaz	43453	PRSL160A	1.4350E+10	1.2915E+10	10.00%
Juana Diaz, PR	Villalba	43453	PRSL160A	8.7778E+11	6.0664E+11	30.89%
Juana Diaz, PR	Villalba	43453	PRSL260A	6.7910E+10	5.4008E+10	20.47%
San Juan, PR	Coamo	79093	PRSL260A	7.2363E+10	2.8952E+10	59.99%
San Juan, PR	Orocovis	79093	PRSL260A	3.9242E+09	1.5700E+09	59.99%

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)	WLA FC (#/yr)	Reduction (%)
Yauco, PR	Yauco	97561	PRSL68A	1.1986E+10	1.0788E+10	10.00%
Yauco, PR	Yauco	97561	PRSL69A	1.0015E+11	7.0983E+10	29.12%
San Juan, PR	Cayey	79093	PRSR54A--2	1.7758E+09	5.8336E+05	99.97%
San Juan, PR	Salinas	79093	PRSR54A--2	1.5914E+10	4.9423E+07	99.69%
San Juan, PR	Cayey	79093	PRSR54A--3	1.7357E+09	6.4348E+08	62.93%
San Juan, PR	Cayey	79093	PRSR54A--4	2.3997E+10	1.6198E+10	32.50%
San Juan, PR	Salinas	79093	PRSR54A--4	8.0151E+10	5.4069E+10	32.54%
Juana Diaz, PR	Juana Diaz	43453	PRSR61A	9.6559E+10	1.8145E+08	99.81%
Juana Diaz, PR	Villalba	43453	PRSR61A	5.9528E+07	1.0157E+07	82.94%
Yauco, PR	Guayanilla	97561	PRSR67A	4.8707E+11	1.5007E+11	69.19%
Yauco, PR	Yauco	97561	PRSR67A	2.5338E+10	1.1024E+10	56.49%
Yauco, PR	Guayanilla	97561	PRSR68A	5.3730E+09	4.8357E+05	99.99%
Yauco, PR	Yauco	97561	PRSR68A	8.9816E+11	6.1075E+10	93.20%
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRSR69A1	7.1596E+09	4.8327E+09	32.50%
Yauco, PR	Guanica	97561	PRSR69A1	1.3371E+11	8.4430E+10	36.86%
Yauco, PR	Sabana Grande	97561	PRSR69A1	5.7077E+09	3.2915E+09	42.33%
Yauco, PR	Yauco	97561	PRSR69A1	4.4996E+11	2.8778E+11	36.04%
Mayaguez, PR	Hormigueros	55738	PRWR77A	6.5504E+11	4.0841E+11	37.65%
Mayaguez, PR	Mayaguez	55738	PRWR77A	1.1394E+09	7.5514E+07	93.37%
Mayaguez, PR	San German	55738	PRWR77A	4.1398E+10	1.5800E+10	61.83%
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	PRWR77A	3.4347E+10	2.2917E+10	33.28%
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRWR77A	7.4426E+11	1.5569E+11	79.08%
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77A	1.1590E+12	4.4450E+11	61.65%
Mayaguez, PR	Hormigueros	55738	PRWR77B	9.3779E+10	6.3301E+10	32.50%
Mayaguez, PR	Mayaguez	55738	PRWR77B	5.5631E+11	3.7551E+11	32.50%
Mayaguez, PR	Hormigueros	55738	PRWR77C	1.0299E+11	3.3725E+10	67.26%
Mayaguez, PR	Mayaguez	55738	PRWR77C	3.4723E+10	8.4570E+09	75.64%
Mayaguez, PR	San German	55738	PRWR77C	5.5434E+10	2.6339E+10	52.49%
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	PRWR77D	8.3865E+11	5.6609E+11	32.50%
San German--Cabo Rojo--Sabana Grande, PR	Lajas	78985	PRWR77D	5.5291E+08	3.7321E+08	32.50%
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77D	3.4163E+11	2.3060E+11	32.50%
Mayaguez, PR	San German	55738	PRWR77E	2.1799E+11	1.4715E+11	32.50%
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77E	1.9736E+11	1.3322E+11	32.50%
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77F	4.7668E+11	1.9831E+11	58.40%
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRWR77G	1.6488E+08	1.1130E+08	32.50%
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77G	1.1602E+11	7.8313E+10	32.50%
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRWR77H	2.7417E+11	1.0947E+11	60.07%
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	PRWR77H	3.5509E+10	1.3608E+10	61.68%
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	PRWR77I	2.2530E+11	1.2699E+11	43.64%
Guayama, PR	Guayama	35866	UCW--10	9.8859E+09	8.8444E+09	10.53%
Guayama, PR	Salinas	35866	UCW--10	7.2992E+09	6.5693E+09	10.00%

Urbanized Area	County	Urbanized Area Code	Assessment Unit ID	Baseline FC (#/yr)	WLA FC (#/yr)	Reduction (%)
Guayama, PR	Arroyo	35866	UCW--13	7.3253E+15	4.2589E+12	99.94%
Guayama, PR	Guayama	35866	UCW--13	7.5270E+14	4.9077E+11	99.93%
Fajardo, PR	Luquillo	28981	UCW--25	1.8050E+16	8.8041E+15	51.22%
San Juan, PR	Canovanas	79093	UCW--25	1.6210E+16	1.4589E+16	10.00%
San Juan, PR	Loiza	79093	UCW--25	4.9594E+16	4.4507E+16	10.26%
San Juan, PR	Rio Grande	79093	UCW--25	5.5924E+16	3.6143E+15	93.54%
San Juan, PR	Maunabo	79093	UCW--32	1.9507E+15	1.5547E+15	20.30%
San Juan, PR	Yabucoa	79093	UCW--32	1.2356E+15	8.7648E+14	29.07%
San Juan, PR	Humacao	79093	UCW--33	4.1985E+15	3.3968E+15	19.09%
San Juan, PR	Yabucoa	79093	UCW--33	5.2616E+14	4.0740E+14	22.57%
Ponce, PR	Penuelas	70642	UCW--35	7.7850E+10	1.9990E+09	97.43%
Ponce, PR	Ponce	70642	UCW--35	4.6588E+11	3.9756E+11	14.66%
San Juan, PR	San Juan	79093	UCW--40	2.4711E+16	2.2240E+16	10.00%
Guayama, PR	Salinas	35866	UCW--7	5.6809E+10	5.1128E+10	10.00%
Aguadilla--Isabela--San Sebastian, PR	Camuy	00631	UNC--2	1.0566E+11	9.5097E+10	10.00%
Aguadilla--Isabela--San Sebastian, PR	Lares	00631	UNC--2	6.7823E+11	6.1040E+11	10.00%
Aguadilla--Isabela--San Sebastian, PR	Quebradillas	00631	UNC--2	3.5041E+09	3.1537E+09	10.00%
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	UNC--2	1.4429E+09	1.2986E+09	10.00%
Arecibo, PR	Arecibo	03034	UNC--2	4.0472E+12	3.6425E+12	10.00%
Arecibo, PR	Camuy	03034	UNC--2	2.2898E+12	2.0609E+12	10.00%
Arecibo, PR	Hatillo	03034	UNC--2	3.8473E+12	3.4625E+12	10.00%
Arecibo, PR	Quebradillas	03034	UNC--2	2.0029E+12	1.8026E+12	10.00%
Aguadilla--Isabela--San Sebastian, PR	Aguadilla	00631	UNC--3	3.8598E+12	1.5369E+12	60.18%
Aguadilla--Isabela--San Sebastian, PR	Isabela	00631	UNC--3	3.0454E+12	1.8399E+12	39.58%
Aguadilla--Isabela--San Sebastian, PR	Moca	00631	UNC--3	2.7881E+11	7.1391E+10	74.39%
Aguadilla--Isabela--San Sebastian, PR	San Sebastian	00631	UNC--3	2.1918E+10	4.8060E+08	97.81%
San Juan, PR	Canovanas	79093	URGL	2.9683E+16	2.6715E+12	99.99%
San Juan, PR	Loiza	79093	URGL	7.3358E+15	6.6022E+11	99.99%
San German--Cabo Rojo--Sabana Grande, PR	Lajas	78985	UVL-E	6.6462E+11	1.8046E+11	72.85%
San German--Cabo Rojo--Sabana Grande, PR	Sabana Grande	78985	UVL-E	3.1961E+11	2.3207E+10	92.74%
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	UVL-E	2.3573E+10	7.2665E+07	99.69%
Yauco, PR	Guanica	97561	UVL-E	1.0420E+11	9.3147E+10	10.61%
Yauco, PR	Lajas	97561	UVL-E	1.2903E+10	1.0307E+10	20.12%
Yauco, PR	Sabana Grande	97561	UVL-E	1.1767E+11	7.9774E+09	93.22%
San German--Cabo Rojo--Sabana Grande, PR	Cabo Rojo	78985	UVL-W	1.4974E+11	7.6698E+10	48.78%
San German--Cabo Rojo--Sabana Grande, PR	Lajas	78985	UVL-W	1.4445E+11	3.4031E+10	76.44%
San German--Cabo Rojo--Sabana Grande, PR	San German	78985	UVL-W	2.6234E+10	7.8386E+07	99.70%

Table 5-4. Individual NPDES permitted facility WLAs

Permit	Pipe	Facility Name	Assessment Unit ID	Permitted Load (#/yr)	WLA (#/yr)	WLA (#/100mL)	Reduction (%)
PR0000477	5	RIMCO INC	PREQ14D	0.00E+00	0.00E+00	200	
PR0022471	1	PRASA WTP GUZMAN ARRIBA	PREE16A	2.79E+11	2.79E+11	200	0.00%
PR0022829	1	PRASA WTP HUMACAO LAS PIEDRAS	PREE33A	9.39E+11	9.39E+11	200	0.00%
PR0001091	1	R.J. REYNOLDS TOBACCO (CI)	PREE35A	2.98E+11	2.98E+11	200	0.00%
PR0022799	1	PRASA WTP GUAYABOTA	PREE35A	8.29E+10	8.29E+10	200	0.00%
PR0025402	1	MARCOS SANCHEZ S.U. SCHOOL	PREE35A	6.63E+10	3.32E+10	200	50.00%
PR0021717	1	PRASA YABUCOA STP	PREK35.1	4.15E+13	4.15E+12	200	90.00%
PR0022837	1	PRASA WTP YABUCOA	PREK35.1	1.33E+11	1.33E+11	200	0.00%
PR0025577	1	LA GLORIA WARD SCHOOL	PREQ14E	1.66E+11	1.66E+10	200	90.00%
PR0022438	1	PRASA WTP GUAYNABO	PRER12A1	6.55E+12	6.55E+12	200	0.00%
PR0022543	1	PRASA - CIDRA WTP	PRER12A2	5.53E+12	5.53E+11	200	90.00%
PR0022420	1	PRASA WTP CANOVANAS	PRER14B	NMR	4.42E+12	200	-
PR0022462	1	PRASA WTP CUBUY	PRER14B	NMR	3.18E+11	200	-
PR0025241	1	ESCUELA SECUNDARIA BARRIO CUBU	PRER14B	2.96E+11	2.96E+10	200	90.00%
PR0020656	1	PRASA MAUNABO	PRER37A	2.76E+12	2.76E+12	200	0.00%
PR0025143	1	ESC AIBONITO BELTRAN	PRNL3A1	6.91E+09	6.91E+09	200	0.00%
PR0025879	1	PRASA LARES	PRNR3A2	3.33E+12	3.33E+12	200	0.00%
PR0026450	1	PRASA LARES WTP	PRNR3A2	8.62E+11	8.62E+11	200	0.00%
PR0025852	1	PRASA REAL ANON FILTER PLANT	PRSE61A	1.19E+11	1.19E+11	200	0.00%
PR0020494	1	PRASA GUAYANILLA	PRSR67A	1.71E+12	1.71E+12	200	0.00%
PR0024678	1	PRASA JAGUA-PASTO FILTER PLNT	PRSR67A	1.99E+11	1.99E+11	200	0.00%
PR0021661	1	PRASA YAUCO STP	PRSR68A	5.71E+13	5.71E+12	200	90.00%
PR0020818	1	PRASA SAN GERMAN	PRWR77A	2.21E+13	2.21E+13	200	0.00%
PR0022977	1	PRASA WTP SAN GERMAN	PRWR77A	NMR	4.50E+11	200	-
PR0024007	1	PRASA WTP SABANA GRANDE	PRWR77A	NMR	1.99E+11	200	-
PR0025542	1	PRASA SABANA GRANDE STP	PRWR77A	2.76E+12	2.76E+12	200	0.00%
PR0020648	1	PRASA MARICAO	PRWR77C	4.84E+12	4.84E+11	200	90.00%
PR0022969	1	PRASA WTP MARICAO FILTER PLANT	PRWR77C	6.56E+12	6.56E+11	200	90.00%
PR0026204	1	PRASA - CAIN ALTO WTP	PRWR77F	8.57E+10	8.57E+10	200	0.00%
PR0026131	1	PRASA - LA MAQUINA WTP	PRWR77H	5.97E+10	5.97E+10	200	0.00%
PR0023264	1	PRASA RIO GRANDE ESTATES	UCW--25	2.07E+12	2.07E+12	200	0.00%
PR0023931	1	PRASA EL YUNQUE FILTRATION PLT	UCW--25	6.08E+13	6.08E+12	200	90.00%
PR0026425	1	COCO BEACH WTP	UCW--25	2.76E+13	2.76E+12	200	90.00%
PR0024163	1	PRASA WTP HATILLO	UNC--2	1.77E+11	1.77E+11	200	0.00%
PR0022918	1	PRASA WTP AGUADILLA FILTER PLT	UNC--3	5.26E+12	5.26E+12	200	0.00%
PR0024015	1	PRASA WTP RAMEY PLANT	UNC--3	2.39E+11	2.39E+11	200	0.00%
PR0020575	1	PRASA LAJAS	UVL-E	3.32E+12	3.32E+12	200	0.00%

6 REASONABLE ASSURANCE AND TMDL IMPLEMENTATION

6.1 Reasonable Assurance

There is reasonable assurance that the goals of these TMDLs can be met with proper watershed planning, implementing pollution reduction of the best management practices (BMPs), and strong political and financial mechanisms. Reasonable assurance that the TMDLs established will require a comprehensive, adaptive approach that addresses the following:

- Nonpoint source pollution including failing septic systems
- Existing and future sources
- Regulatory and voluntary approaches

TMDLs represent an attempt to quantify the pollutant load that can be present in a waterbody and still ensure attainment and maintenance of water quality standards. These TMDLs identify the necessary overall load reductions for fecal coliform bacteria causing use impairments and distributes those reduction goals to the appropriate sources. Reaching the reduction goals established by these TMDLs will occur through nonpoint source controls to achieve LAs and the NPDES and permits to achieve WLAs.

The nonpoint source controls can be implemented through a number of existing programs such as section 319 of the Clean Water Act commonly referred to as the Nonpoint Source Program. This program can help with installing BMPs that prevent or reduce nonpoint source pollution to a level compatible with water quality goals.

According to 40 CFR 122.44(d)(1)(vii)(B), the effluent limitations for an NPDES permit must be consistent with the assumptions and requirements of any available WLA for the discharge prepared by the state and approved by EPA. Furthermore, EPA has authority to object to issuance of an NPDES permit that is inconsistent with WLAs established for that point source. This applies to traditional point sources as well as more diffuse sources such as permitted MS4 systems.

6.2 Implementation

These TMDLs are based on attaining an in-stream geomean fecal coliform bacteria concentration of 200 colonies/100 mL (minimum five samples) and a dual target of no more than 20 percent of samples exceeding 400 colonies/100 mL (see Section 2.2). The TMDLs in this report meet these standards, have been calculated at each assessment unit pour point, and require a wide range of reductions in fecal coliform bacteria loading to meet the standard. The TMDL implementation plan focuses on increased reductions from existing sources of fecal coliform bacteria. Managing future sources, such as new development, falls under the category of watershed planning.

Effective watershed planning is a critical component for meeting water quality standards in the future. It is recognized that implementing watershed management strategies has already occurred to some extent in the watershed. However, to meet the targeted load reductions, additional implementation practices must occur in the future.

Several critical questions should be addressed during the TMDL implementation phase. These are presented as a basis for evaluating an implementation strategy and to ensure that adequate resources are provided to meet the fecal coliform bacteria reduction goals specified in Section 5. Some of the key programmatic questions and answers are listed below, these include the following:

How much fecal coliform bacteria must be reduced?

Section 5 identifies the necessary fecal coliform bacteria load reductions for the entire watershed, listed by assessment unit and source as calculated as part of this TMDL analysis.

Do programs and organizations exist to address the reductions from nonpoint sources?

An effective management plan must address the capability of local, territorial, and federal programs to implement the management strategies recommended in this implementation plan. Identifying and assigning actions to appropriate organizations is part of implementation. Some of those organizations might include EPA, PREQB, Puerto Rico Natural Resource Conservation Service, University of Puerto Rico Agricultural Extension Offices, local watershed associations and environmental groups.

What monitoring information would help to meet the necessary reductions?

This TMDL presents sources of fecal coliform bacteria loading based on in-stream monitoring, modeling results, and land use data. Further data collection regarding specific sources can be used to refine the management plan. For example, septic failure rates were assumed to be uniform throughout the watershed because of a lack of data or log of failures. Further data collection to refine the failure rate in the watershed could be performed to verify the assumed failure rate and assist in focusing BMP implementation more effectively. For assumptions and limitations with respect to these TMDLs, see Section 4.3.

How should load reductions be prioritized?

While there are variations in the percent reductions necessary to achieve TMDL compliance by assessment unit, pollutant load is fairly evenly distributed throughout the watershed. Thus, the following management recommendations are for the watershed as a whole.

6.2.1 Management Plan: Agricultural Areas

Agriculture includes farming of plant crops and animal husbandry. Because large areas of land are devoted to these activities, they have a significant impact on water quality and water resources. Agricultural effects on water resources generally involve several types of pollutants: (1) Nutrients, (2) Pesticides, (3) Bacteria and Viruses, (4) Sediments, and (5) Erosion. For the purposes of this management plan, reductions of bacteria will be the primary focus of management recommendations. However, because many of the same management practices will also contribute to load reductions in other pollutants, implementing proposed fecal coliform bacteria reducing management measures would contribute to improved overall water quality within the watershed. To improve water quality, farmers can apply a variety of measures to minimize runoff of potentially harmful materials (e.g., animal wastes) from agricultural lands into adjacent streams and, ultimately, surface waters in the watershed.

6.2.1.1 Implementation: Agricultural Areas

To achieve realistic reductions in fecal coliform bacteria load and concentrations in the watershed, the following framework is provided:

1. Using GIS land use data and animal census data, locate and identify the most significant farming activities and source areas with the highest potential fecal coliform bacteria load.
2. Develop a suite of educational, technical and financial resources to address the issues deemed most significant, including the following:
    - Develop a schedule for implementation of pilot scale and demonstration projects and monitor the results.
    - Reassess implementation schedule as a result of monitoring results and revise program accordingly.
    - Implement actions on lower priority land uses and activities as higher priority areas are completed, assessed, and begin to come into compliance.

It is recognized that current programs have been implemented in recent years to address the goal of reducing fecal coliform bacteria loading to receiving waters. However, on the basis of in-stream monitoring and modeling results, additional BMP implementation must occur to meet the load reductions specified in this TMDL.

6.2.1.2 Recommended BMPs: Agricultural Areas

Education should occur on a variety of levels and target decision makers (elected officials, heads of agencies, and political appointees), farm owners and farm workers, and the general public. The importance of protecting natural resources and the effect of nonpoint source pollution must be communicated effectively, focusing on linkages between healthy natural resources, clean drinking water, and a strong economy.

Public education and outreach activities and materials can take on a variety of forms, depending on the target audience:

- Decision makers need general information on the effects of nonpoint source pollution, how nonpoint source pollution affects the environment, ways of controlling nonpoint source pollution, and how the adverse effects of nonpoint source pollution affect the economy and aesthetics of the region.
- Farmers need detailed information on how to select and implement proper nonstructural and structural BMPs, operate and maintain structural BMPs, recognize the limitations of the land and obtain the maximum sustainable yield within those limitations, manage land properly, and develop and implement control plans.

- The general public needs to understand the linkages between their actions, nonpoint source pollution, and degradation of the natural environment.
- Education programs should be tailored to the specific needs of the community, the needs of the farmers, and the education level of the target audiences.

An effective strategy for public education and outreach regarding agricultural nonpoint source pollution should include the following:

- Developing a commission or similar mechanism for coordinating educational policy for the region
- Community education programs
- Field demonstrations and follow-up site visits
- School and community workshops
- Outreach and extension programs, including courses for farm workers
- Using media (TV, radio, videos, and such)
- Require school environmental education curriculum
- Developing outreach materials such as fact sheets, guidance documents, and courses for decision makers, farmers, and the general public
- Educating political and policy leaders in the watershed
- Designate one responsible or lead coordinating agency
- Economic incentives for implementing education programs

Achieving the successful implementation of BMPs by farmers hinges on demonstrating to them that adopting such practices can save money, resources, and time.
Education and outreach programs should focus on working with farmers and others to implement the following BMPs, which emphasize reducing fecal coliform bacteria loading:

Keep Livestock Out of Water. By cutting off the access of livestock to streams, ponds, and rivers with fencing, animal contact with waterborne bacteria is reduced and animal discharge of bacteria is minimized.

Provide Alternative Watering Holes. To deter livestock grazing, farmers must provide an alternative source of drinking water for their livestock.

Disposal of Dead Livestock. Dead livestock should be disposed of properly to reduce the potential for ground and surface water contamination from pathogens. They should be removed from streams or fields and isolated until disposal is possible. Proper disposal methods include composting and incineration. Incineration facilities require more detailed planning and need to be developed under the consultation of local, territorial, and national authorities to ensure proper construction, operation, and maintenance.

Divert Runoff Water. Diverting clean water around a feedlot prevents the excessive erosion of manure solids from the lot and increases the effectiveness of settling basins or other solid-liquid separation equipment. Prevent rainwater from entering the feedlot by using gutters and downspouts to handle water coming from building rooftops.

Manure Management. A complete manure management system involves collection, storage (temporary or long-term), and ultimate disposal or use. A manure management plan should establish fertilizer plans to use manure effectively.

Store Livestock Wastes Properly. Waste storage structures should not be near surface waters. Also, farmers should take special precautions when storing waste in earthen structures to prevent wastes from seeping through the bottom of the basin to adjacent surface waters or groundwater. Manure storage areas should be covered when possible.

Composting Manure. This practice is an aerobic process of controlled biodegradation of animal wastes that reduces pathogens and stabilizes nutrients. It is a highly cost-effective technique of managing wastes, producing a valuable commodity, and reducing potential for water resource contamination. Composting requires active management to produce a useful soil amendment.

Filter Strips. These are vegetated zones around a confined animal facility or active cropland that trap sediments, organic wastes and other pollutants in stormwater runoff. Farmers must regularly maintain them to function effectively. Constructed wetlands in low-lying areas can also serve a similar purpose.

Heavy Use Area Protections. This practice involves constructing hard surfaces in heavily used areas. Materials for construction can be concrete, asphalt, compacted gravel or compacted earth, depending on the waste management objectives. Hardening areas of heavy use prevents or slows their physical degradation and facilitates the collection and use of animal wastes, the latter being vital to protecting water resources.

Manure Stacking Areas. These areas are temporary locations for storing animal wastes in a field before application. Their purpose is to supplement constructed storage facility volumes or to await favorable conditions for field application.

Manure Storage Facilities. This BMP involves using permanent structures for temporarily storing animal wastes. They also capture polluted runoff and are therefore a useful means of preventing or minimizing transport of contaminants and sediments to surface waters.

Manure and Waste Utilization Plans. These are plans that formulate an approach to recycling animal wastes to benefit crop production while ensuring environmental quality. They can be used in conjunction with nutrient management plans to minimize the amount of commercial fertilizer applied to cropland.

Other BMPs that might be useful in managing animal wastes include the following:

- Using waste storage ponds and waste treatment lagoons
- Reusing runoff water or manure for agricultural crops or plantings

- Contracting with commercial rendering or disposal services

Reducing Wastewater and Runoff from Confined Animal Facility. This involves limiting surface water runoff and discharge from confined animal facilities to adjacent streams or the river. This can be done by storing both the facility wastewater and the stormwater runoff and managing the stored runoff and pollutants through an appropriate waste use system. Some BMPs for reducing animal facility runoff include the following:

- Using dikes, diversions, and grassed waterways
- Protecting heavy use areas
- Using lined waterways or outlets
- Managing roof runoff and runoff from paved areas
- Terracing slopes
- Using waste storage ponds or waste storage structures such as waste treatment lagoons
- Reusing runoff water or manure for agricultural crops or plantings
- Waste use and recycling
- Providing a composting facility
- Using commercial rendering or disposal services
- Incinerating wastes
- Using approved burial sites
- Using structures to trap sediments and associated pollutants (sediment basin, water and sediment control basin)
- Using vegetated filter strips and constructed wetlands to trap sediments and associated pollutants

Grazing Management. This BMP protects water resources by managing livestock range, pasture, and other grazing lands to reduce erosion, sedimentation, and transport of pollutants in the following ways:

- Using deferred grazing and planned grazing to allow water resources and land to recover from intensive use that can damage water quality
- Proper grazing use
- Proper woodland grazing
- Pasture and hayland management
- Using pipelines, wells, ponds, drinking water troughs or tanks to water livestock instead of natural streams or ponds
- Spring development

Irrigation Water Management. This BMP reduces nonpoint pollution of surface and groundwaters caused by irrigation. Such measures include the following:

- Irrigation water management and scheduling

- Using irrigation water-measuring devices
- Soil and crop water use data
- Irrigation system, drip or trickle
- Irrigation system, sprinkler
- Irrigation system, surface and subsurface
- Irrigation system, tailwater recovery
- Irrigation field ditch
- Irrigation land leveling
- Filter strip
- Surface drainage field ditch
- Subsurface drain
- Water table control
- Controlled drainage
- Backflow prevention practices

Financial Incentives. Financial incentives should be a component of the agricultural management plan. Grants and government programs could be directed to farmers for implementing BMPs. For example, government agencies could implement manure-recycling programs by purchasing manure from livestock farmers and storing the manure properly until it can be donated as fertilizer. Other cost sharing measures should be offered to provide incentive for BMP implementation.

6.2.2 Management Plan: Urban Areas

Land development and construction activities typically involve clearing and removing vegetation, grading the land surface, excavating earth, removing and importing soil, constructing impervious structures using man-made building materials, installing utilities, constructing septic or sewer systems, building roads, and landscaping. Such activities also affect water quality by removing protective vegetation, stormwater runoff from cleared areas and lawns, spilling paint or other compounds, dust from construction materials, and fertilizers and pesticides used in landscaping.

Existing urban land uses contribute to nonpoint source pollutant loading from a variety of sources and activities, including increased flow and wash off of accumulated pollutants from impervious surfaces, accelerated upland and channel erosion, pet waste, sanitary sewer overflows and combined sewer overflows, and failing septic systems.

6.2.2.1 Implementation: Urban Areas

To achieve realistic reductions in fecal coliform bacteria load and concentration in the watershed, the following framework is provided:

1. A program should be developed to assess the discrete effects of permitted (MS4s) and non-permitted loads from urban areas.

2. Using GIS land use data, locate and identify the most significant land use source areas with the highest potential load.
3. Develop a suite of educational, technical, and financial resources to address the issues deemed most significant, including the following:
    - Develop a schedule for implementation of ordinances, pilot scale and demonstration projects and monitor the results
    - Reassess implementation schedule as a result of monitoring results and revise program accordingly
    - Implement actions on lower priority sources as higher priorities are completed, assessed, and come into compliance

6.2.2.2 Recommended BMPs: Urban Areas

BMPs for urban land uses are designed to reduce the effects of these sources on surface waters. After implementing BMPs, their effectiveness should be evaluated in relation to prescribed WLAs (MS4s), and future permit conditions will be established with a goal of water quality standard compliance. Typical measures for construction sites include sediment traps and basins; sediment fences; wind erosion controls; and sediment, chemical, and nutrient control. Although these BMPs target sediment, bacteria are also targeted inherently because bacteria sources can be associated with sediment. Because urbanization is ongoing, it is useful to consider BMPs that address existing UAs as well as future growth. Therefore, BMPs for urban land uses should be considered in three phases of development: Pre-Construction (or Planning), Construction, and Post-Construction.

Education focused on urban residents, businesses, and decision makers is essential to the success of BMPs. As with agricultural BMPs, public education and outreach activities can take on a variety of forms, depending on the target audience.

- Decision makers and residents need general information on the effects of nonpoint source pollution, how nonpoint source pollution affects the environment, ways of controlling nonpoint source pollution, and how the adverse effects of nonpoint source pollution affect the economy and aesthetics of the region.
- Businesses and commercial users need detailed and focused information on how to select and implement proper nonstructural and structural BMPs, operate and maintain structural BMPs, manage land properly, and develop and implement erosion and sediment control plans.
- Education programs should be tailored to the specific needs of the community and the education level of the target audiences.

An effective strategy for public education and outreach regarding urban nonpoint source pollution should include the following:

- Developing a commission or similar mechanism for coordinating educational policy for the region
- Community education programs
- Field demonstrations and follow-up site visits

- School and community workshops
- Outreach and extension programs, including courses for commercial, industrial and residential users
- Using media (TV, radio, videos, and others)
- Required school environmental education curriculum
- Developing outreach materials such as fact sheets, guidance documents, and courses for decision makers, residents, businesses and the general public
- Educating political and policy leaders in the Watershed
- Appointing one responsible or lead coordinating agency
- Economic incentives for implementing education programs

Achieving the successful implementation of BMPs by citizens hinges on demonstrating to them that adopting such practices can save money, resources, and time. Education and outreach programs can focus on working with citizens and others to implement the following BMPs.

<u>Pre-Construction (Planning) Phase:</u>

Develop a spill response plan that clearly outlines procedures to be followed if an accidental spill occurs on-site during construction (e.g., sewer line damage).

Plan access roads to reduce stream crossings to minimize the amount of sediment-associated pollutants that wash into tributaries.

<u>Construction Phase</u>:

Locate on-site pollutant sources away from drainage courses to prevent pollutants from being washed into drainage courses and streams during rainfall events.

Install sedimentation basins to collect stormwater runoff from construction activities.

Install anchored mulch (especially on slopes greater than 5 percent and concentrated flow areas such as diversions and waterway channels). Examples of mulch include mats, chemical mulches and organic mulches (hay, wood chips, shredded corn stalks).

Sediment barriers (hay bales, silt fencing) that are installed along the slope contour (at the same elevation) with ends flared uphill successfully capture runoff.

Minimize soil disturbance at construction projects in areas with steep slopes and close proximity to surface waters need to minimize the amount of road access and exposed soil.

Construct entrance pads at construction sites.

Vehicle washing keeps sediment and soil on-site.

Post-Construction Phase:

Vegetated filter strips are areas of land with natural or planted vegetation designed to receive overland sheet runoff from upgradient development. The primary function of the strips is to remove pollutants from the flow before it reaches surface water.

Grassed swales are shallow, vegetated, man-made ditches designed so that the bottom elevation is above the groundwater table to allow runoff to infiltrate into the ground.

Grassed waterways (wide, shallow channels lined with sod) are often used as outlets for runoff from terraces.

Extended detention ponds are structures that are designed to temporarily hold stormwater for up to 24 hours, a period long enough to allow for settling of particulates. These ponds are normally dry between storm events, but may have a shallow marsh in the detention area.

Wet ponds are designed to have a permanent pool of water with additional capacity to detain stormwater. The pool prevents the resuspension of sediments in the pond from previous storm events. Wet ponds can achieve a high degree of pollutant removal and peak stormwater discharge reduction.

Constructed wetlands are engineered systems designed to replicate some of the beneficial functions of natural wetlands to treat and contain stormwater runoff pollutants and reduce peak flow. Constructed wetlands are complex systems and require careful planning if they are to function properly.

Infiltration practices including ponds and trenches are designed to allow stormwater runoff to collect and permeate into the ground. By infiltrating the runoff, pollutants will be retained in the soil. However, a major drawback to infiltration practices is their high maintenance requirements.

6.2.3 Management Plan: Septic Systems

Approximately 32% and 4% of the population is serviced by on-site septic systems and latrine systems, respectively. These systems effectively remove fecal coliform bacteria when properly installed and maintained as fecal coliform bacteria naturally die off while the effluent percolates through the soil to the groundwater. These systems fail when there is a discharge of waste to the soil surface where it is available for washoff into surface waters.

Failing septic systems can deliver high bacteria loads to surface waters, depending on the proximity of the discharge to a waterbody and the timing of rainfall events. Septic system failures typically occur in older systems that are not adequately maintained with periodic sewage pump-outs.

6.2.3.1 Implementation: Septic Systems

Strategies for septic system management include:

- surveying and testing programs to identify failing septic systems;
- education on proper maintenance of septic systems;
- encouragement to make repairs; and
- studies to evaluate alternatives.

Septic failures are often not evident, and identification of failing septic systems should represent a significant portion of the implementation plan. As failed systems are identified, repairs or alternative systems can be encouraged and incorporated.

Public education regarding proper use and maintenance of septic systems is also important in the implementation process. A significant number of septic failures may be prevented if proper maintenance is conducted. Therefore, a public awareness component should be employed.

Septic alternative studies may provide sufficient information to assist in evaluating alternatives to septic systems. Suitability studies for selecting appropriate septic systems (latrines vs. septic tanks or leachfields) can be developed based on soil type and other physical characteristics that may provide selection criteria.

6.2.3.2 Recommended BMPs: Septic Systems

If additional septic system reductions/controls beyond those outlined earlier are necessary, studies are recommended to be undertaken to assess the reduction of fecal coliform as a result of the proposed septic system alternatives. PREQB in consultation with local governments should determine whether additional treatment requirements such as clustered treatment and/or on-site upgrades, or sewering with centralized treatment and discharge out of the watersheds are necessary to achieve these TMDLs.

BMP pollutant removal efficiencies for septic systems are largely dependent on site-specific characteristics that dictate the design and placement of these features. Therefore, recommendations for BMPs should be made on a case by case basis, or clustered depending on the type of management.

6.2.4 Additional Programs and Initiatives

The following additional programs and initiatives will also result in reductions in fecal coliform:

The Livestock Permit and Compliance Division (LPCD) of EQB's Water Quality Area operates a program to help ensure that owners of livestock enterprises design, implement and operate a systematic approach to managing the fecal animal waste. To achieve these the livestock enterprises must submit an Animal Waste Management Plan that establishes BMPs for managing their fecal animal waste. The plan includes the methods for collecting, storing and adequately disposing of the fecal animal waste. The plan's main purpose is to focus on preventing water, air and land contamination and its consequences. In addition to undertaking compliance efforts within the sub-basin of Río Grande de Manatí, EQB developed a management plan for the restoration of watersheds. The strategy includes actions for the following activities:

- Increasing the number of monitoring stations to obtain additional water quality data;
- Promoting the implementation of BMPs, such as vegetation management techniques, that will reduce nutrients, pesticides, fertilizers and sediments in runoff;
- Excluding cattle from the river; and
- Targeting educational efforts at farmers and landowners.

The Puerto Rico Aqueduct and Sewer Authority Watershed Stewardship Initiative (PRASA-WSI) is a cooperative effort among regulators and the regulated community to establish watershed management plans for watersheds that serve as a significant source of drinking water and receive significant effluent from PRASA wastewater and drinking water plants. Pilots and practices used in the Loiza and LaPlata Watersheds are expected serve as examples and a guide for approaches that could be used throughout Puerto Rico:

- rain gardens/green technologies demonstration (University of Puerto Rico);
- PREQB/DNER On-Site System Operation & Maintenance for homeowners training;
- municipal commitments for on-site pump outs for four pilot municipalities at low or no cost to residents; and
- efforts to revise construction permitting legislation to improve the on-site systems permitting process island-wide.

6.2.5 Authorities and Agency Directives

Reductions can be realized through the implementation of authorities and agency directives listed below as well.

Article VI of the Puerto Rico Constitution, 1 L.P.R.A. § 19 provides that: "It shall be the public policy of The Commonwealth to conserve, develop and use its natural resources in the most effective manner possible for the general welfare community".

Puerto Rico Environmental Public Policy Act, Act No.416 of September 22, 2004, as amended (12 L.P.R.A. §8001, et seq.) grants EQB authority to exercise, execute, receive and administer the delegation of federal programs and to establish and implement regulations and a permit system related to, but not limited to, the Federal Clean Water Act, Clean Air Act, Solid Waste Disposal Act, Resource Conservation and Recovery Act, Comprehensive Environmental Response Compensation and Liability Act, and any other environmental legislation that might be enacted by Congress. Act No. 416 also establishes an environmental public policy, an Environmental Review Process (ERP) and related requirements, and provides for environmental causes of action, enforcement and penalties sufficient to assure program implementation even in the absence of other authorities.

Under Act No. 416 EQB has approved the Puerto Rico Water Quality Standards Regulation, the Regulation of Evaluation and Processing of Environmental Document, and Regulations for the Control of Hazardous and Non-Hazardous Solid Wastes. Act No. 416 is also EQB's legal base for implementing its Nonpoint Source Program, developed and approved under Section 319 of the CWA.

Under the Organic Act of the Department of Natural and Environmental Resources, Act No. 23 of June 20, 1972, as amended (3 L.P.R.A. 151, et seg.), the Department of Natural and Environmental Resources (DNER)[3] is responsible for implementing the natural resources protection public policy of the Commonwealth of Puerto Rico, as contained in Article VI of the Puerto Rico Constitution, in conjunction with EQB and in accordance with Act No. 9. The Organic Act of the DNER and other specific statutes grant the agency regulatory authority over the use and conservation of natural resources, surface and underground waters, land resources, fish and marine resources, wildlife, plant species, submerged lands and mining resources, among others. In addition, the DNER is the agency responsible for administering the Puerto Rico Coastal Management Program.

Under the Act for the Conservation, Development, and Use of the Water Resources of Puerto Rico, Act No. 136 of June 3, 1976, as amended (12 L.P.R.A. §1501, et seq.) the Secretary of the DNER has the powers and duties, among others, 1) to adopt regulations pertaining to uses and areas of use of the bodies of water, the quantity which may be withdrawn or otherwise use in each water body, forestation of riparian areas, lakes, lagoons and dams, recovery of land, reclaiming of flooded areas, and other aspects; and 2) to recommend to the Planning Board the adoption of standards and regulations relative to the development and use of lands that affect the water resources.

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[3] This agency is also known as the Departamento de Recursos Naturales y Ambientales (DRNA) in Puerto Rico.

Under the Puerto Rico Planning Board Organic Act, Act No. 75 of June 24, 1975, as amended (23 L.P.R.A. §62, et seq.), the Puerto Rico Planning Board (PB) is responsible for guiding Puerto Rico's integral development and promoting the efficient use of land and other natural resources. The Puerto Rico Planning Board Organic Act grants the agency specific powers and duties such as preparing an Integral Development Plan, Land Use Plans and a Four Year Investment Program; promulgating zoning maps and regulations, as well as for ruling on land use and development projects siting proposals. The PB is bound to comply with the environmental public policy and the process of environmental review, mandated by EQB Act 416. On the other hand, the EQB’s public policies must conform to the policies of the PB and the goals contained in the Plan of Integral Development for Puerto Rico.

The PB is bound by the environmental public policy and the environmental review process mandated by EQB's Act No. 416. On the other hand, EQB's public policies must conform to the PB policies and objectives contained in the Integral Development Plan for Puerto Rico.

The Permit Office Management (OGPe By their initials in Spanish), it is created on the basis of Law No. 161 (23 L.P.R.A §-9011, et seq.), known "Law for the reform of the process of permissions of Puerto Rico". This Act establishes that the OGPe, will be the Office responsible for issuing final determinations and permits, licenses, inspections, certifications and any such authorization or procedure that is necessary to respond to requests for citizenship. Facilitate and promote the sustainable comprehensive, economic, social and physical development of Puerto Rico which will result in the growth of more, better and different industries and the creation of jobs in the private sector.

The Department of Agriculture (DA) is responsible for the formulation and implementation of the public policy and general directives related to the agricultural development of Puerto Rico under the Organic Act of the Department of Agriculture, Act No. 60 of April 25, 1940 (3 L.P.R.A. §381, et seg.), the Act of the Soil Conservation Districts, Act 211 of March 26, 1946 (5 L.P.R.A. §241, et seq.), and the Pesticides Act of Puerto Rico, Act No. 49 of June 10, 1953, as amended (5 L.P.RA §1001, et seq.). It is the agency responsible for regulating, planning, coordinating and supervising the agricultural sector. Among the specific statutory and regulatory responsibilities of the DA that are relevant to nonpoint source control are: pesticide and herbicide sale, distribution and application under the Pesticides Act of Puerto Rico and its regulation; milk and beef cattle, swine and poultry and horse industries; and fertilizers manufacturing, sale, distribution and application.

6.2.6 Effectiveness of Proposed Watershed Management Measures

The potential effectiveness of the suggested management measures will largely depend on the watershed-wide implementation success as well as the effectiveness of the individual practices. The amount of research conducted on the efficiency of BMPs in reducing pollutant transport to receiving waters has grown steadily in recent years.

However, land use-based BMP pollutant removal efficiencies are largely dependent on site-specific characteristics that dictate the design and placement of these features. Efficiency data based on local BMP implementation projects should be reviewed rather than literature values or regional efficiency data to guide the implementation process. Based on accurate pollutant removal estimates, an informed strategy for attainment of the TMDL can be developed, implemented, and verified by future monitoring.

Recommended future monitoring locations include the discharge point of each assessment unit (Figure 5-1). Monitoring at the calibration station would provide a continuous flow record that would provide historical data and ongoing record during TMDL implementation process. Monitoring conducted at assessment unit pour points will provide estimates of implementation.

While ideally all subwatersheds should be monitored at their discharge points, limited resources may be available to establish year round sampling at all of these locations.
At a minimum, flow in the stream should be measured concurrently and weather condition should be noted. The current sampling schedule for these stations is 3 times a year, an increase in the frequency of sampling is recommended. Fecal coliform bacteria samples will be collected by trained personnel and tested by a certified laboratory. The analysis method should be the following: Fecal coliform bacteria, M-FC MF (0.7 micron) method, water, colonies per 100 milliliters.

Additionally, it would be useful to monitor fecal coliform concentrations during the rising, peak and recession of the streamflow hydrograph for a storm that occurs after a period of dry weather. This would allow for an evaluation of the surface accumulation and washoff rates of fecal coliform bacteria. This special monitoring effort could be done once a year.

In addition to fecal coliform bacteria and flow, several other water quality parameters should normally be sampled and the data recorded by trained volunteers. These include pH, dissolved oxygen, biological oxygen demand (BOD), temperature, conductivity, and turbidity. Observations regarding the condition of the stream and adjacent areas should be made.

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APPENDIX A: SANITARY SYSTEM TYPE

Municipality	Sewered Households, Census 1990	Households on Septic, Census 1990	Household on "other," Census 1990	Total Households, Census 1990	% Sewered Households, Census 1990	% Households on Septic, Census 1990	% Household on "other," Census 1990
Adjuntas	1814	3773	696	6283	28.87%	60.05%	11.08%
Aguada	3223	7722	908	11853	27.19%	65.15%	7.66%
Aguadilla	10592	9359	810	20761	51.02%	45.08%	3.90%
Aguas Buenas	2163	5411	464	8038	26.91%	67.32%	5.77%
Aibonito	3894	3545	408	7847	49.62%	45.18%	5.20%
Añasco	3100	4939	484	8523	36.37%	57.95%	5.68%
Arecibo	16396	14682	1380	32458	50.51%	45.23%	4.25%
Arroyo	3366	2580	481	6427	52.37%	40.14%	7.48%
Barceloneta	2880	4125	216	7221	39.88%	57.13%	2.99%
Barranquitas	2378	4986	258	7622	31.20%	65.42%	3.38%
Bayamón	61493	8743	453	70689	86.99%	12.37%	0.64%
Cabo Rojo	5962	9513	1170	16645	35.82%	57.15%	7.03%
Caguas	32191	10345	757	43293	74.36%	23.90%	1.75%
Camuy	2485	6751	429	9665	25.71%	69.85%	4.44%
Canóvanas	4774	6244	596	11614	41.11%	53.76%	5.13%
Carolina	55292	6216	395	61903	89.32%	10.04%	0.64%
Cataño	10114	549	81	10744	94.14%	5.11%	0.75%
Cayey	8969	5723	693	15385	58.30%	37.20%	4.50%
Ceiba	3658	1668	199	5525	66.21%	30.19%	3.60%
Ciales	1516	3840	371	5727	26.47%	67.05%	6.48%
Cidra	2972	7094	627	10693	27.79%	66.34%	5.86%
Coamo	4433	5919	565	10917	40.61%	54.22%	5.18%
Comerío	2012	3564	762	6338	31.75%	56.23%	12.02%
Corozal	3093	6602	246	9941	31.11%	66.41%	2.47%
Culebra	56	397	205	658	8.51%	60.33%	31.16%
Dorado	5358	5026	115	10499	51.03%	47.87%	1.10%
Fajardo	10481	3092	291	13864	75.60%	22.30%	2.10%
Florida	1705	926	272	2903	58.73%	31.90%	9.37%
Guánica	3285	3586	692	7563	43.44%	47.42%	9.15%
Guayama	9119	3382	1094	13595	67.08%	24.88%	8.05%
Guayanilla	2475	3471	976	6922	35.76%	50.14%	14.10%
Guaynabo	21950	9142	360	31452	69.79%	29.07%	1.14%
Gurabo	4492	4555	319	9366	47.96%	48.63%	3.41%
Hatillo	2608	7410	797	10815	24.11%	68.52%	7.37%
Hormigueros	2592	2535	144	5271	49.17%	48.09%	2.73%
Humacao	10900	6595	847	18342	59.43%	35.96%	4.62%
Isabela	4060	8891	546	13497	30.08%	65.87%	4.05%
Jayuya	1463	2810	300	4573	31.99%	61.45%	6.56%
Juana Díaz	4466	7838	1192	13496	33.09%	58.08%	8.83%
Juncos	4278	5510	447	10235	41.80%	53.83%	4.37%
Lajas	2249	5505	1111	8865	25.37%	62.10%	12.53%
Lares	2911	5642	771	9324	31.22%	60.51%	8.27%

Municipality	Sewered Households, Census 1990	Households on Septic, Census 1990	Household on "other," Census 1990	Total Households, Census 1990	% Sewered Households, Census 1990	% Households on Septic, Census 1990	% Household on "other," Census 1990
Las Marías	650	1822	732	3204	20.29%	56.87%	22.85%
Las Piedras	3401	4921	480	8802	38.64%	55.91%	5.45%
Loíza	4024	3964	322	8310	48.42%	47.70%	3.87%
Luquillo	4974	2424	132	7530	66.06%	32.19%	1.75%
Manatí	7153	5877	307	13337	53.63%	44.07%	2.30%
Maricao	707	1096	486	2289	30.89%	47.88%	21.23%
Maunabo	1335	1840	706	3881	34.40%	47.41%	18.19%
Mayagüez	24436	10422	1090	35948	67.98%	28.99%	3.03%
Moca	2667	7030	757	10454	25.51%	67.25%	7.24%
Morovis	1952	4780	639	7371	26.48%	64.85%	8.67%
Naguabo	2899	4385	407	7691	37.69%	57.01%	5.29%
Naranjito	1796	5897	883	8576	20.94%	68.76%	10.30%
Orocovis	1961	3513	874	6348	30.89%	55.34%	13.77%
Patillas	1963	3914	724	6601	29.74%	59.29%	10.97%
Peñuelas	1608	4238	975	6821	23.57%	62.13%	14.29%
Ponce	46322	11695	2195	60212	76.93%	19.42%	3.65%
Quebradillas	1305	5531	269	7105	18.37%	77.85%	3.79%
Rincón	1299	3455	232	4986	26.05%	69.29%	4.65%
Río Grande	8070	6469	539	15078	53.52%	42.90%	3.57%
Sábana Grande	3495	4161	477	8133	42.97%	51.16%	5.86%
Salinas	4314	4267	1416	9997	43.15%	42.68%	14.16%
San Germán	5394	5947	1068	12409	43.47%	47.92%	8.61%
San Juan	158859	7729	1391	167979	94.57%	4.60%	0.83%
San Lorenzo	4132	6249	1010	11391	36.27%	54.86%	8.87%
San Sebastián	4385	8317	834	13536	32.40%	61.44%	6.16%
Santa Isabel	3332	2534	449	6315	52.76%	40.13%	7.11%
Toa Alta	6237	6719	420	13376	46.63%	50.23%	3.14%
Toa Baja	16959	10221	828	28008	60.55%	36.49%	2.96%
Trujillo Alto	12439	6289	587	19315	64.40%	32.56%	3.04%
Utuado	3604	7015	1193	11812	30.51%	59.39%	10.10%
Vega Alta	4220	6259	682	11161	37.81%	56.08%	6.11%
Vega Baja	8214	9451	653	18318	44.84%	51.59%	3.56%
Vieques	1010	2057	262	3329	30.34%	61.79%	7.87%
Villalba	1485	4457	724	6666	22.28%	66.86%	10.86%
Yabucoa	4608	5818	836	11262	40.92%	51.66%	7.42%
Yauco	6352	5962	1768	14082	45.11%	42.34%	12.56%
TOTAL	710779	426931	51275	1188985	59.78%	35.91%	4.31%

APPENDIX B: TIDAL PRISM MODEL

The tidal prism model assumes that a single control volume can represent a waterbody and that the pollutant is well-mixed in the waterbody system.

The mass balance of water can be written as follows (Guo and Lordi 2000):

$$\frac{dV}{dT} = (Q_0 - Q_b + Q_f) \qquad (1)$$

where

Q_0 is the quantity of water that enters the embayment on the flood tide through the ocean boundary (m^3 per tidal cycle)
Q_b is the quantity of mixed water that leaves the bay on the ebb tide that did not enter the bay on the previous flood tide (m^3 per tidal cycle)
Q_f is total freshwater input (m^3 per tidal cycle)
V is the volume of the bay (m^3)
T is the dominant tidal period (hours)

It is further assumed that Q_0 is the pure ocean water that did not flow out of the embayment on the previous ebb tide and that Q_b is the embayment water that did not enter into the system on the previous flood tide. The mass balance for the fecal coliform bacteria can then be written as follows:

$$V\frac{dC}{dT} = Q_0C_0 - Q_bC + L_f - kVC \qquad (2)$$

where

L_f ($Q_f . C_f$) is the loading from upstream in the tidal cycle
k is the fecal coliform bacteria decay rate (or a damped parameter for the net loss of fecal coliform bacteria)
C is fecal coliform bacteria concentration in the embayment
C_0 is the fecal coliform bacteria concentration from outside the embayment

In a steady-state condition, the mass balance equations for the water can be written as follows:

$$Q_b = Q_0 + Q_f \qquad (3)$$

A numerical solution for equation (2) can be developed for the fecal coliform bacteria concentration to simulate a time-variable result by substituting finite difference approximations for the derivatives. The fecal coliform bacteria concentration in the embayment can be calculated from equation (2) as follows:

$$Q_0C_0 - Q_bC^{i+1} + Q_fC_f - kVC^{i+1} = V\frac{C^{i+1} - C^i}{\Delta t} \qquad (4)$$

$$C^{i+1} = \frac{[\Delta t/V\,(Q_0 C_0 + L_f) + C_i]}{[1 + \Delta t/V\,(Q_b + kV)]} \quad (5)$$

The daily load can be estimated on the basis of the dominant tidal period in the area. The dominant tidal period was assumed to be approximately 12 hours. If fecal coliform bacteria concentration is in MPN/100 mL, the daily load (counts day^{-1}) can be estimated as follows:

$$Load = Load_T \times \frac{24}{12} \times 10000 \quad (6)$$

Because Q_0 (the quantity of water that enters the embayment on the flood tide through the ocean boundary) is unknown, it was determined indirectly.

Usually Q_0 is not known, and the only known quantity at the ocean boundary is the tidal range of the tidal embayment. A tidal range time series was computed for the dominant tidal period using observed hourly data from the San Juan, PR, station (NOAA/NOS # 9755371). From that, Q_T (the total ocean water entering the bay on the flood tide) can be calculated. Q_T can then be used to calculate Q_0 (the volume of new ocean water entering the embayment on the flood tide) by using the ocean tidal exchange ratio β:

$$Q_0 = \beta \cdot Q_T \quad (7)$$

where β is the exchange ratio, and Q_T is the total ocean water entering the bay on the flood tide. The numerical value of β is usually smaller than 1, and it represents the fraction of new ocean water entering the embayment.

In general, the exchange ratio values range from 0.3 to 0.7 (VDEQ 2005; Kuo et al. 1998; Shen et al. 2002). Once Q_0 is known, Q_b can be calculated from equation (3).

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APPENDIX C: MODEL FILES AND CALIBRATION/VALIDATION SHEETS

This document is accompanied by the following files:

- Flow_WQ_Weather_Data
  - WEATHER <DIR>
    - Weather_Stations_East.jpg
    - Weather_Stations_West.jpg
    - Weather_Summary.xlsx
  - maps <DIR>
    - Colocated_Stations_East.jpg
    - Colocated_Stations_West.jpg
    - STORET_WQ_Stations_East.jpg
    - STORET_WQ_Stations_West.jpg
    - USGS_Flow_Gages_East.jpg
    - USGS_Flow_Gages_West.jpg
    - USGS_WQ_Stations_East.jpg
    - USGS_WQ_Stations_West.jpg

- LSPC
  - LSPCModel.exe
  - Puerto_Rico.mdb
  - baseline_200.inp
  - tmdl_200_reduce.inp
  - LSPC_PR_1_28_2011.inp
  - Weather <DIR>
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    - 665911.air
    - 666073.air
    - 666083.air
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- PR8816.air
- PR8881.air
- PR9829.air

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  - Puerto_Rico_working.mdb
  - database.inp

- Calib-Valid_spreadsheets
  - WQCalib_15002_50138800.xls
  - HydroCal_2007_10040_50100450.xlsm
  - HydroCal_2007_10084_50106100.xlsm
  - HydroCal_2007_11055_50114000.xlsm
  - HydroCal_2007_12063_50124200.xlsm
  - HydroCal_General_1044_50010500.xls
  - HydroCal_General_4004_50049100.xls
  - HydroCal_General_5003_50061800.xls
  - HydroCal_General_6020_50063800.xls
  - HydroCal_General_7006_50071000.xls
  - HydroCal_General_8027_50083500.xls
  - HydroCal_General_9032_50092000.xls
  - HydroCal_General_14038_50138000.xls
  - WQCalib_1033_50011400.xls
  - WQCalib_1044_50010500.xls
  - WQCalib_3005_50048510.xls

- WQCalib_4004_50049100.xls
- WQCalib_5003_50061820.xls
- WQCalib_6020_50063800.xls
- WQCalib_7006_50071000.xls
- WQCalib_8027_50083500.xls
- WQCalib_9032_50092000.xls
- WQCalib_10083_50106500.xls
- WQCalib_11055_50114000.xls
- WQCalib_12060_50124700.xls
- WQCalib_13031_50129700.xls
- WQCalib_14038_50138000.xls

APPENDIX D: SUBBASIN LAND USE AREA

This document is accompanied by a MS Spreadsheet: “LU_by_sws.xls”

APPENDIX E: CAFO LOADS BY PERMIT

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
2005	UNC--1	DAIRY COW	240	Pasture	EPV-07-0012	JAVIER BARRETO MENA	1.0080E+11	2.4192E+13
2005	UNC--1	DAIRY COW	97	Pasture	EPV-47-0006	JOSE A. MARTINEZ VARELA	1.0080E+11	9.7776E+12
2005	UNC--1	DAIRY COW	450	Pasture	EPV-47-0001	MODESTO ESPINOZA	1.0080E+11	4.5360E+13
2005	UNC--1	DAIRY COW	118	Pasture	EPV-28-0005	GILBERTO SOTO	1.0080E+11	1.1894E+13
2005	UNC--1	DAIRY COW	82	Pasture	EPV-28-0004	ANIBAL MARTINEZ	1.0080E+11	8.2656E+12
2005	UNC--1	DAIRY COW	95	Pasture	EPV-28-0002	MIGUEL VEGA CRESPI	1.0080E+11	9.5760E+12
2005	UNC--1	DAIRY COW	211	Pasture	EPV-07-0103	ELOY BARRETO(BARRETO DAIRY IN	1.0080E+11	2.1269E+13
2005	UNC--1	DAIRY COW	212	Pasture	EPV-07-0097	CARLOS CARDONA Y GLADYS RODRI	1.0080E+11	2.1370E+13
2005	UNC--1	DAIRY COW	104	Pasture	EPV-07-0092	MANUEL LOPEZ MART═NEZ (REYES	1.0080E+11	1.0483E+13
2005	UNC--1	DAIRY COW	95	Pasture	EPV-07-0073	AGR═COLA RAMON ROSA DELGADO (	1.0080E+11	9.5760E+12
2005	UNC--1	DAIRY COW	136	Pasture	EPV-07-0048	OSCAR F. VARELA	1.0080E+11	1.3709E+13
2005	UNC--1	DAIRY COW	52	Pasture	EPV-47-0010	JUAN AULET MENDEZ	1.0080E+11	5.2416E+12
2005	UNC--1	DAIRY COW	110	Pasture	EPV-07-0016	JAIME RODRIGUEZ VARELA	1.0080E+11	1.1088E+13
2002	UNC--1	DAIRY COW	141	Pasture	EPV-07-0007	RAM╙N ROSA DELAGADO	1.0080E+11	1.4213E+13
2005	UNC--1	HOG	45	Agriculture	EPP-09-0006	JESUS SANTANA	1.0800E+10	4.8600E+11
2005	UNC--1	HOG	139	Agriculture	EPP-07-0050	FRANCISCA MASTACHE	1.0800E+10	1.5012E+12
2005	UNC--1	HOG	15	Agriculture	EPP-07-0021	HECTOR LOPEZ	1.0800E+10	1.6200E+11
2005	UNC--1	HOG	484	Agriculture	EPP-07-0016	ISRAEL VEGA ROJAS	1.0800E+10	5.2272E+12
2005	UNC--1	HOG	203	Agriculture	EPP-07-0013	EDWIN PADRO RIVERA INSTITUCIO	1.0800E+10	2.1924E+12
2005	UNC--1	HOG	18	Agriculture	EPP-07-0005	HECTOR M. SERRANO	1.0800E+10	1.9440E+11
2005	UNC--1	HOG	2022	Agriculture	EPP-07-0001	EUFEMIO RODR═GUEZ RUIZ	1.0800E+10	2.1838E+13
2005	UNC--1	HORSE	8	Pasture	EPO-07-0002	ESTEBAN MENA	4.2000E+08	3.3600E+09
2002	UNC--1	DAIRY COW	169	Pasture	EPV-07-0057	NELSON RAMOS IRIZARRY	1.0080E+11	1.7035E+13
2002	UNC--1	HOG	18	Agriculture	EPP-07-0024	JOSE DIAZ REYES	1.0800E+10	1.9440E+11
2002	UNC--1	CHICKEN	50000	Agriculture	EPA-07-0003	MARIO MILANES	1.3600E+08	6.8000E+12
2005	UNC--1	DAIRY COW	70	Pasture	EPV-07-0019	JOSE LOPEZ CACERES	1.0080E+11	7.0560E+12
2002	UNC--1	HOG	118	Agriculture	EPP-07-0023	MELVIN RIOS	1.0800E+10	1.2744E+12
2001	PRNE7.1	DAIRY COW	238	Pasture	EPV-07-0040	JOSE A. DELGADO FERNANDEZ	1.0080E+11	2.3990E+13
2000	PRNE7.1	HORSE	13	Pasture	EPO-07-0005	RAFAEL CARDONA (HACIENDA SAN	4.2000E+08	5.4600E+09
2001	PRNE7.1	BEEF COW	249	Pasture	EPO-07-0004	JOSE A. LOPEZ CACERES	1.0400E+11	2.5896E+13

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
2001	PRNE7.1	DAIRY COW	98	Pasture	EPV-07-0017	JOSE RICARDO SOTO	1.0080E+11	9.8784E+12
2001	PRNE7.1	DAIRY COW	90	Pasture	EPV-07-0028	EMILIO VELEZ MOLINA	1.0080E+11	9.0720E+12
2001	PRNE7.1	DAIRY COW	430	Pasture	EPV-07-0042	Jose Lopez Caceres	1.0080E+11	4.3344E+13
2001	PRNE7.1	DAIRY COW	850	Pasture	EPV-07-0079	Q- DEVELOPMENT INC. (JOSE A.	1.0080E+11	8.5680E+13
2004	PRNE7.1	DAIRY COW	539	Pasture	EPP-07-0030	WILLIAM ROJAS ALICEA	1.0080E+11	5.4331E+13
2004	PRNE7.1	DAIRY COW	292	Pasture	EP-V07-0075	AGRICOLA RAMON ROSA DELGADO,	1.0080E+11	2.9434E+13
2001	PRNE7.1	DAIRY COW	132	Pasture	EPV-07-0022	SAMUEL QUILES	1.0080E+11	1.3306E+13
2004	PRNE7.1	DAIRY COW	158	Pasture	EPV-09-0002	ANDR╔S RAMOS REYES	1.0080E+11	1.5926E+13
13035	UVL-E	DAIRY COW	58	Pasture	EPV-41-0004	ROBERTO CARLO	1.0080E+11	5.8464E+12
13035	UVL-E	HOG	416	Agriculture	EPP-41-0007	ESTACION EXPERIMENTAL AGR═COL	1.0800E+10	4.4928E+12
13035	UVL-E	DAIRY COW	421	Pasture	EPV-41-0003	EJA DAIRY INC. (VAQUERIA SAN	1.0080E+11	4.2437E+13
13035	UVL-E	DAIRY COW	97	Pasture	EPV-41-0001	ESTACION EXPERIMENTAL DE LAJA	1.0080E+11	9.7776E+12
13035	UVL-E	DAIRY COW	135	Pasture	EPV-41-0006	LA PLATA FARM INC.	1.0080E+11	1.3608E+13
13049	UVL-E	CHICKEN	28000	Agriculture	EPA-41-0001	GRANJA LA TEA CORP (HECTOR GO	1.3600E+08	3.8080E+12
13049	UVL-E	RABBIT	148	Agriculture	EPO-41-0003	ESTACION EXPERIMENTAL AGR═COL	1.2500E+08	1.8500E+10
13049	UVL-E	RABBIT	188	Agriculture	EPO-41-0004	JOSE MIGUEL TORO ITURRINO	1.2500E+08	2.3500E+10
13049	UVL-E	HOG	45	Agriculture	EPP-41-0003	JAIME O. CAMACHO RODR═GUEZ	1.0800E+10	4.8600E+11
13110	UVL-W	HOG	41	Agriculture	EPP-41-0010	JOSE C. RODRIGUEZ	1.0800E+10	4.4280E+11
1061	UNC--2	DAIRY COW	237	Pasture	EPV-34-0104	CARLOS TOLEDO MONROIG	1.0080E+11	2.3890E+13
1061	UNC--2	DAIRY COW	178	Pasture	EPV-34-0097	ADOLFO GARCIA AMADOR	1.0080E+11	1.7942E+13
1061	UNC--2	DAIRY COW	65	Pasture	EPV-34-0103	JUAN FELIX BARRETO	1.0080E+11	6.5520E+12
1061	UNC--2	DAIRY COW	157	Pasture	EPV-34-0096	JORGE DELGADO	1.0080E+11	1.5826E+13
1061	UNC--2	DAIRY COW	51	Pasture	EPV-34-0105	MELVIN DELGADO	1.0080E+11	5.1408E+12
1061	UNC--2	DAIRY COW	350	Pasture	EPV-34-0111	JOSE MIGUEL TALAVERA RODRIGUE	1.0080E+11	3.5280E+13
1061	UNC--2	DAIRY COW	115	Pasture	EPV-34-0116	JOSE TORRADO PEREZ	1.0080E+11	1.1592E+13
1061	UNC--2	DAIRY COW	207	Pasture	EPV-34-0118	BENJAMIN RODRIGUEZ RIOS	1.0080E+11	2.0866E+13
1061	UNC--2	DAIRY COW	79	Pasture	EPV-34-0121	EDWIN VELEZ	1.0080E+11	7.9632E+12
1061	UNC--2	DAIRY COW	120	Pasture	EPV-34-0089	OMAR ORTEGA CLAUDIO	1.0080E+11	1.2096E+13
1061	UNC--2	DAIRY COW	116	Pasture	EPV-34-0119	JUAN HERRERA SIBERIO VAQ. CAC	1.0080E+11	1.1693E+13
1061	UNC--2	DAIRY COW	92	Pasture	EPV-34-0082	OVIDIO PERAZA	1.0080E+11	9.2736E+12
1061	UNC--2	DAIRY COW	185	Pasture	EPV-34-0080	DEMETRIO AMADOR	1.0080E+11	1.8648E+13

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
1061	UNC--2	DAIRY COW	116	Pasture	EPV-34-0074	FELIX MERINO HERMIDA	1.0080E+11	1.1693E+13
1061	UNC--2	DAIRY COW	328	Pasture	EPV-34-0069	JUAN PERAZA MORA	1.0080E+11	3.3062E+13
1061	UNC--2	DAIRY COW	60	Pasture	EPV-34-0067	IVAN AMADOR TORRES	1.0080E+11	6.0480E+12
1061	UNC--2	DAIRY COW	176	Pasture	EPV-34-0066	JOSE R GONZALEZ ALFONSO	1.0080E+11	1.7741E+13
1061	UNC--2	DAIRY COW	137	Pasture	EPV-34-0062	GLORIMAR BARRETO	1.0080E+11	1.3810E+13
1061	UNC--2	DAIRY COW	60	Pasture	EPV-34-0053	RUBEN ROSA CARDONA	1.0080E+11	6.0480E+12
1061	UNC--2	DAIRY COW	160	Pasture	EPV-34-0126	ALBERTO JAVIER PEREZ DORTA	1.0080E+11	1.6128E+13
1061	UNC--2	DAIRY COW	444	Pasture	EPV-34-0046	JOSE A. LOPEZ CACERES (SAN AN	1.0080E+11	4.4755E+13
1062	UNC--2	DAIRY COW	115	Pasture	EPV-07-0065	RAMON MEDINA	1.0080E+11	1.1592E+13
1061	UNC--2	DAIRY COW	150	Pasture	EPV-34-0044	JORGE LUCENA BETANCOURT	1.0080E+11	1.5120E+13
1061	UNC--2	DAIRY COW	408	Pasture	EPV-34-0050	JOSE A. LOPEZ CACERES (VAQ. S	1.0080E+11	4.1126E+13
1061	UNC--2	DAIRY COW	291	Pasture	EPV-34-0037	VLADIMIR TORRADO ROSA	1.0080E+11	2.9333E+13
1062	UNC--2	DAIRY COW	41	Pasture	EPV-34-0127	GREGORIO TOLEDO QUINTANA	1.0080E+11	4.1328E+12
1062	UNC--2	DAIRY COW	216	Pasture	EPV-34-0115	ISAAC ESPINOSA ESPINOSA	1.0080E+11	2.1773E+13
1062	UNC--2	DAIRY COW	222	Pasture	EPV-34-0100	VAQUERIA LA MARIPOSA JOSE R	1.0080E+11	2.2378E+13
1062	UNC--2	DAIRY COW	41	Pasture	EPV-34-0091	JORGE GARCIA RUIZ	1.0080E+11	4.1328E+12
1062	UNC--2	DAIRY COW	380	Pasture	EPV-34-0081	SUCN. MODESTO ESPINOZA	1.0080E+11	3.8304E+13
1062	UNC--2	DAIRY COW	205	Pasture	EPV-34-0077	JUAN HERNANDEZ	1.0080E+11	2.0664E+13
1062	UNC--2	DAIRY COW	392	Pasture	EPV-34-0045	SUCN. MODESTO ESPINOSA	1.0080E+11	3.9514E+13
1062	UNC--2	DAIRY COW	389	Pasture	EPV-34-0039	LUIS CORDERO TOLEDO	1.0080E+11	3.9211E+13
1062	UNC--2	DAIRY COW	120	Pasture	EPV-34-0021	JOSE RODRIGUEZ	1.0080E+11	1.2096E+13
1062	UNC--2	DAIRY COW	85	Pasture	EPV-07-0078	ALFREDO PEREZ NIEVES	1.0080E+11	8.5680E+12
1062	UNC--2	DAIRY COW	135	Pasture	EPV-07-0053	SUCN. PROVIDENCIO VELEZ (ADA	1.0080E+11	1.3608E+13
1062	UNC--2	DAIRY COW	50	Pasture	EPV-07-0071	EDGARDO MORA	1.0080E+11	5.0400E+12
1061	UNC--2	DAIRY COW	90	Pasture	EPV-34-0129	JUAN MORA ROMAN	1.0080E+11	9.0720E+12
1062	UNC--2	DAIRY COW	275	Pasture	EPV-07-0063	JOS╓ L. RODR═GUEZ	1.0080E+11	2.7720E+13
1062	UNC--2	DAIRY COW	277	Pasture	EPV-07-0029	ROBERTO TOLEDO BONETA	1.0080E+11	2.7922E+13
1062	UNC--2	DAIRY COW	446	Pasture	EPV-07-0026	JORGE LUCENA BETANCOURT	1.0080E+11	4.4957E+13
1062	UNC--2	DAIRY COW	283	Pasture	EPV-07-0018	ALBERTO TOLEDO DELGADO	1.0080E+11	2.8526E+13
1062	UNC--2	HOG	68	Agriculture	EPP-07-0004	MIGUEL GONZALEZ	1.0800E+10	7.3440E+11
1061	UNC--2	DAIRY COW	109	Pasture	EPV-34-0139	LUIS H. BORGES HERNANDEZ	1.0080E+11	1.0987E+13
1061	UNC--2	DAIRY COW	124	Pasture	EPV-34-0137	LUIS JIRAU JIMENEZ	1.0080E+11	1.2499E+13

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
1061	UNC--2	DAIRY COW	190	Pasture	EPV-34-0136	REYNALDO DORTA	1.0080E+11	1.9152E+13
1061	UNC--2	DAIRY COW	830	Pasture	EPV-34-0135	GUSTAVO TOLEDO	1.0080E+11	8.3664E+13
1061	UNC--2	DAIRY COW	60	Pasture	EPV-34-0132	MIGUEL ROMAN VAZQUEZ	1.0080E+11	6.0480E+12
1062	UNC--2	DAIRY COW	452	Pasture	EPV-07-0074	JOSE RODRIGUEZ (LUCHO)	1.0080E+11	4.5562E+13
1047	UNC--2	DAIRY COW	340	Pasture	EPV-59-0026	JOSE GREGORIO TOLEDO	1.0080E+11	3.4272E+13
1048	UNC--2	DAIRY COW	306	Pasture	EPV-14-0040	BENJAMIN RODRIGUEZ RAMOS	1.0080E+11	3.0845E+13
1047	UNC--2	DAIRY COW	227	Pasture	EPV-59-0006	JOSE TRORRADO PEREZ	1.0080E+11	2.2882E+13
1047	UNC--2	DAIRY COW	134	Pasture	EPV-59-0008	JESUS JAVIER TOLEDO DIAZ	1.0080E+11	1.3507E+13
1047	UNC--2	DAIRY COW	60	Pasture	EPV-59-0009	JESUS ROMAN MORALES	1.0080E+11	6.0480E+12
1047	UNC--2	DAIRY COW	76	Pasture	EPV-59-0011	ANGEL SAAVEDRA	1.0080E+11	7.6608E+12
1047	UNC--2	DAIRY COW	114	Pasture	EPV-59-0013	JOSE A. NIEVES OCASIO	1.0080E+11	1.1491E+13
1047	UNC--2	DAIRY COW	185	Pasture	EPV-59-0004	ALVIN DORTA DORTA	1.0080E+11	1.8648E+13
1047	UNC--2	DAIRY COW	110	Pasture	EPV-59-0019	LUIS MARTINEZ MARTINEZ	1.0080E+11	1.1088E+13
1047	UNC--2	DAIRY COW	130	Pasture	EPV-59-0002	EDGARDO SOTO AVILA	1.0080E+11	1.3104E+13
1047	UNC--2	DAIRY COW	266	Pasture	EPV-59-0030	JOS╓ G. TOLEDO	1.0080E+11	2.6813E+13
1048	UNC--2	CHICK EN	20000	Agriculture	EPA-59-0001	H╓CTOR RIVERA LAUREANO	1.3600E+08	2.7200E+12
1048	UNC--2	DAIRY COW	330	Pasture	EPV-14-0012	JOSE L. PEREZ PADIN	1.0080E+11	3.3264E+13
1048	UNC--2	DAIRY COW	505	Pasture	EPV-14-0013	SUCN. MODESTO ESPINOZA	1.0080E+11	5.0904E+13
1048	UNC--2	DAIRY COW	214	Pasture	EPV-14-0021	CARLOS ESPINOSA	1.0080E+11	2.1571E+13
1048	UNC--2	DAIRY COW	358	Pasture	EPV-14-0025	JORGE MACHADO	1.0080E+11	3.6086E+13
1061	UNC--2	DAIRY COW	340	Pasture	EPV-34-0043	GUSTAVO TOLEDO TOLEDO	1.0080E+11	3.4272E+13
1047	UNC--2	DAIRY COW	250	Pasture	EPV-59-0017	JOS╓ G. TOLEDO TOLEDO	1.0080E+11	2.5200E+13
1047	UNC--2	DAIRY COW	197	Pasture	EPV-14-0027	LUIS D. HERNANDEZ RIVERA	1.0080E+11	1.9858E+13
1047	UNC--2	HORSE	13	Pasture	EPO-14-0004	LUIS M. MORELL MORELL	4.2000E+08	5.4600E+09
1047	UNC--2	HOG	171	Agriculture	EPP-59-0004	AXEL ARIEL RIVERA MEDINA	1.0800E+10	1.8468E+12
1047	UNC--2	DAIRY COW	115	Pasture	EPV-14-0003	LUIS SOTO Y HECTOR VIDOT	1.0080E+11	1.1592E+13
1047	UNC--2	DAIRY COW	155	Pasture	EPV-14-0008	EDWIN CARDONA	1.0080E+11	1.5624E+13
1047	UNC--2	DAIRY COW	66	Pasture	EPV-14-0010	JOSE ACEVEDO LOPEZ	1.0080E+11	6.6528E+12
1047	UNC--2	DAIRY COW	240	Pasture	EPV-14-0016	LUIS RENE DELGADO PEREZ	1.0080E+11	2.4192E+13
1047	UNC--2	DAIRY COW	141	Pasture	EPV-59-0005	JOEL A. DELGADO LOPEZ	1.0080E+11	1.4213E+13
1047	UNC--2	DAIRY COW	180	Pasture	EPV-14-0022	LUIS RENE DELGADO DORTA	1.0080E+11	1.8144E+13
1048	UNC--2	DAIRY COW	172	Pasture	EPV-14-0054	JUAN R. NIEVES OCASIO	1.0080E+11	1.7338E+13

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
1047	UNC--2	DAIRY COW	182	Pasture	EPV-14-0036	MANUEL TOSADO	1.0080E+11	1.8346E+13
1047	UNC--2	DAIRY COW	347	Pasture	EPV-14-0048	BIENVENIDO CORDERO MANGUAL	1.0080E+11	3.4978E+13
1047	UNC--2	DAIRY COW	593	Pasture	EPV-14-0051	JOSE LOPEZ CASERES	1.0080E+11	5.9774E+13
1047	UNC--2	DAIRY COW	107	Pasture	EPV-14-0052	EFRAIN CORDERO VEGA	1.0080E+11	1.0786E+13
1047	UNC--2	DAIRY COW	192	Pasture	EPV-14-0057	BIENVENIDO CORDERO	1.0080E+11	1.9354E+13
1047	UNC--2	DAIRY COW	228	Pasture	EPV-14-0063	CARLOS ROMAN ARBELO	1.0080E+11	2.2982E+13
1047	UNC--2	DAIRY COW	66	Pasture	EPV-14-0067	PABLO AMADOR LLORENS	1.0080E+11	6.6528E+12
1047	UNC--2	DAIRY COW	370	Pasture	EPV-14-0017	LUIS RENE DELGADO DORTA	1.0080E+11	3.7296E+13
1061	UNC--2	DAIRY COW	311	Pasture	EPV-34-0022	JOSE TORRADO TOSADO	1.0080E+11	3.1349E+13
1048	UNC--2	DAIRY COW	170	Pasture	EPV-14-0038	WILFREDO LUCIANO GONZALEZ	1.0080E+11	1.7136E+13
1061	UNC--2	DAIRY COW	160	Pasture	EPV-34-0001	JORGE LUCENA BETANCOURT	1.0080E+11	1.6128E+13
1061	UNC--2	DAIRY COW	220	Pasture	EPV-34-0005	JOSE TORRADO TOSADO	1.0080E+11	2.2176E+13
1061	UNC--2	DAIRY COW	142	Pasture	EPV-34-0006	PEDRO CORDERO SANTIAGO	1.0080E+11	1.4314E+13
1061	UNC--2	DAIRY COW	112	Pasture	EPV-34-0011	ISMAEL DELGADO	1.0080E+11	1.1290E+13
1061	UNC--2	DAIRY COW	157	Pasture	EPV-34-0012	JOSE RODRIGUEZ RAMOS	1.0080E+11	1.5826E+13
1061	UNC--2	DAIRY COW	140	Pasture	EPV-07-0068	JUAN M. BARRETO GINORIO	1.0080E+11	1.4112E+13
1061	UNC--2	DAIRY COW	179	Pasture	EPV-34-0018	Ram≤n Talavera	1.0080E+11	1.8043E+13
1061	UNC--2	DAIRY COW	34	Pasture	EPV-07-0066	MIGUEL RAMOS-DUE╤O ANGEL M. D	1.0080E+11	3.4272E+12
1061	UNC--2	DAIRY COW	303	Pasture	EPV-34-0023	PASTOR J. TOLEDO GONZ┴LEZ	1.0080E+11	3.0542E+13
1061	UNC--2	DAIRY COW	199	Pasture	EPV-34-0024	LUIS SIERRA TOLEDO	1.0080E+11	2.0059E+13
1061	UNC--2	DAIRY COW	485	Pasture	EPV-34-0027	JOSE TALAVERA PEREZ	1.0080E+11	4.8888E+13
1061	UNC--2	DAIRY COW	440	Pasture	EPV-34-0028	GUSTAVO TOLEDO TOLEDO CEIBA D	1.0080E+11	4.4352E+13
1061	UNC--2	DAIRY COW	294	Pasture	EPV-34-0032	ADOLFO GARCIA AMADOR	1.0080E+11	2.9635E+13
1061	UNC--2	DAIRY COW	150	Pasture	EPV-34-0036	ERNESTO VALENTIN VAZQUEZ	1.0080E+11	1.5120E+13
1062	UNC--2	DAIRY COW	122	Pasture	EPV-34-0125	CAYETANO MARTINEZ TALAVERA	1.0080E+11	1.2298E+13
1061	UNC--2	DAIRY COW	174	Pasture	EPV-34-0015	HERMANOS PERAZA TOLEDO INC.	1.0080E+11	1.7539E+13
1048	UNC--2	DAIRY COW	194	Pasture	EPV-59-0020	HECTOR RIVERA FELICIANO	1.0080E+11	1.9555E+13
1048	UNC--2	DAIRY COW	125	Pasture	EPV-14-0055	JOSE JAVIER GARCIA	1.0080E+11	1.2600E+13
1048	UNC--2	DAIRY COW	180	Pasture	EPV-14-0059	PEDRO I. VELEZ	1.0080E+11	1.8144E+13
1048	UNC--2	DAIRY COW	113	Pasture	EPV-14-0068	ALVIN O. MENDEZ MEDINA	1.0080E+11	1.1390E+13
1048	UNC--2	DAIRY COW	145	Pasture	EPV-42-0002	JUAN A. RODRIGUEZ RAMOS	1.0080E+11	1.4616E+13
1048	UNC--2	DAIRY COW	23	Pasture	EPV-42-0003	PABLO PRIETO MARTINEZ	1.0080E+11	2.3184E+12

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
1048	UNC--2	DAIRY COW	91	Pasture	EPV-59-0012	ANDRES MALDONADO	1.0080E+11	9.1728E+12
1061	UNC--2	DAIRY COW	130	Pasture	EPV-07-0099	ISRAEL RODRIGUEZ RAMOS	1.0080E+11	1.3104E+13
1048	UNC--2	DAIRY COW	25	Pasture	EPV-59-0015	HECTOR GONZALEZ NIEVES	1.0080E+11	2.5200E+12
1061	UNC--2	DAIRY COW	135	Pasture	EPV-34-0040	JESUS DIAZ GONZALEZ	1.0080E+11	1.3608E+13
1049	UNC--2	RABBIT	175	Agriculture	EPO-42-0005	BARTOLO RODRIGUEZ SANTIAGO	1.2500E+08	2.1875E+10
1049	UNC--2	HORSE	36	Pasture	EPO-42-0010	ANGEL L. MORALES LOPEZ	4.2000E+08	1.5120E+10
1053	UNC--2	DAIRY COW	551	Pasture	EPV-34-0084	ALBERTO DEL RIO SOTO	1.0080E+11	5.5541E+13
1061	UNC--2	HORSE	5	Pasture	EPO-34-0007	PASTOR TOLEDO	4.2000E+08	2.1000E+09
1061	UNC--2	DAIRY COW	98	Pasture	EPV-07-0001	WILFREDO ROMAN	1.0080E+11	9.8784E+12
1061	UNC--2	DAIRY COW	46	Pasture	EPV-07-0021	JOSE HERRERA	1.0080E+11	4.6368E+12
1061	UNC--2	DAIRY COW	77	Pasture	EPV-07-0052	RUBEN GONZALEZ ECHEVARRIA	1.0080E+11	7.7616E+12
1048	UNC--2	DAIRY COW	64	Pasture	EPV-59-0014	MIGUEL RAMOS CRUZ	1.0080E+11	6.4512E+12
1062	UNC--2	DAIRY COW	107	Pasture	EPV-34-0101	ELVIN BARRETO	1.0080E+11	1.0786E+13
1018	PRNQ1 A	DAIRY COW	121	Pasture	EPV-03-0009	SONIA M. DEL VALLE RIVERA	1.0080E+11	1.2197E+13
1023	PRNQ1 A	DAIRY COW	155	Pasture	EPV-37-0014	HUGO MARTINEZ	1.0080E+11	1.5624E+13
1025	PRNQ1 A	DAIRY COW	189	Pasture	EPV-37-0012	RAFAEL BORGES GUEVARA	1.0080E+11	1.9051E+13
1041	PRNR3 A2	DAIRY COW	23	Pasture	EPV-67-0013	MIGUEL TORRADO P╔REZ	1.0080E+11	2.3184E+12
1045	PRNR3 A2	DAIRY COW	157	Pasture	EPV-67-0067	JOSE RAMOS LEBRON	1.0080E+11	1.5826E+13
1045	PRNR3 A2	DAIRY COW	103	Pasture	EPV-67-0058	JOSE L.RAMOS LEBRON	1.0080E+11	1.0382E+13
1045	PRNR3 A2	DAIRY COW	124	Pasture	EPV-67-0048	ANGEL VARGAS NIEVES	1.0080E+11	1.2499E+13
1045	PRNR3 A2	DAIRY COW	126	Pasture	EPV-67-0042	MAXIMO CARDONA	1.0080E+11	1.2701E+13
1045	PRNR3 A2	DAIRY COW	80	Pasture	EPV-67-0039	RAMON E. NAVEDO RIVERA	1.0080E+11	8.0640E+12
1045	PRNR3 A2	DAIRY COW	68	Pasture	EPV-67-0027	VICTOR SERRANO GARCIA	1.0080E+11	6.8544E+12
1045	PRNR3 A2	DAIRY COW	91	Pasture	EPV-67-0017	WILLIAM HERNANDEZ ROSADO(VAQ	1.0080E+11	9.1728E+12
1045	PRNR3 A2	HOG	252	Agriculture	EPP-67-0005	CESAR FUENTES VELEZ	1.0800E+10	2.7216E+12
1041	PRNR3 A2	DAIRY COW	231	Pasture	EPV-67-0055	LUIS A. DELGADO	1.0080E+11	2.3285E+13
1038	PRNQ3 B	DAIRY COW	155	Pasture	EPV-37-0027	SAMUEL RODRIGUEZ ROSA	1.0080E+11	1.5624E+13
1038	PRNQ3 B	DAIRY COW	699	Pasture	EPV-37-0002	CORPORACION AGRICOLA LA TUNA	1.0080E+11	7.0459E+13
1038	PRNQ3 B	HORSE	30	Pasture	EPO-37-0002	LUIS ROMERO	4.2000E+08	1.2600E+10
1036	PRNL3 A1	DAIRY COW	245	Pasture	EPV-14-0041	ALBERTO DEL RIO SOTO	1.0080E+11	2.4696E+13
1036	PRNL3 A1	DAIRY COW	132	Pasture	EPV-14-0031	IVAN MARTINEZ	1.0080E+11	1.3306E+13
1036	PRNL3 A1	CHICK EN	12000	Agriculture	EPA-14-0002	ISABEL NIEVES LUGO	1.3600E+08	1.6320E+12

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
1035	PRNL3 A1	DAIRY COW	177	Pasture	EPV-67-0050	ANGEL ESPINOSA	1.0080E+11	1.7842E+13
1035	PRNL3 A1	DAIRY COW	239	Pasture	EPV-59-0018	FELIPE VARGAS NIEVES	1.0080E+11	2.4091E+13
1040	PRNL3 A1	DAIRY COW	118	Pasture	EPV-67-0043	NORBERTO AROCHO RIVERA	1.0080E+11	1.1894E+13
1055	PRNR5 A	DAIRY COW	78	Pasture	EPV-72-0001	PEDRO MEDINA SALDA╤A	1.0080E+11	7.8624E+12
1055	PRNR5 A	DAIRY COW	88	Pasture	EPV-72-0009	RAFAEL DEL RIO ESTADES	1.0080E+11	8.8704E+12
1052	PRNE5 A	DAIRY COW	56	Pasture	EPV-14-0014	ALFREDO CRESPO AMADOR	1.0080E+11	5.6448E+12
1051	PRNE5 A	DAIRY COW	327	Pasture	EPV-14-0043	IVAN ROSA TOLEDO	1.0080E+11	3.2962E+13
1051	PRNE5 A	DAIRY COW	250	Pasture	EPV-14-0005	JOSE BARRETO VARGAZ (J B AGRO	1.0080E+11	2.5200E+13
1050	PRNE5 A	DAIRY COW	41	Pasture	EPV-34-0130	JORGE SILVERIO	1.0080E+11	4.1328E+12
1050	PRNE5 A	DAIRY COW	182	Pasture	EPV-34-0030	EDELMIRA TOLEDO	1.0080E+11	1.8346E+13
1050	PRNE5 A	DAIRY COW	258	Pasture	EPV-34-0013	EDGARDO MERCADO ROSA	1.0080E+11	2.6006E+13
1050	PRNE5 A	HOG	100	Agriculture	EPP-34-0030	JAVIER REYES	1.0800E+10	1.0800E+12
1050	PRNE5 A	RABBIT	57	Agriculture	EPO-34-0008	ARISANTO LOPEZ DIAZ	1.2500E+08	7.1250E+09
1029	UNC--3	DAIRY COW	75	Pasture	EPV-37-0025	EL FARMER INC (MIGUEL RAMOS C	1.0080E+11	7.5600E+12
1000	UNC--3	DAIRY COW	163	Pasture	EPV-03-0010	ANDRES RUIZ	1.0080E+11	1.6430E+13
1030	UNC--3	HOG	241	Agriculture	EPP-37-0007	LUIS MARTNEZ GONZALEZ	1.0800E+10	2.6028E+12
1029	UNC--3	DAIRY COW	174	Pasture	EPV-37-0022	JAIME MACHADO ROMAN	1.0080E+11	1.7539E+13
1029	UNC--3	DAIRY COW	62	Pasture	EPV-37-0020	SONIA DEL VALLE RIVERA	1.0080E+11	6.2496E+12
1029	UNC--3	DAIRY COW	55	Pasture	EPV-37-0008	HERMANOS BADILLO INC	1.0080E+11	5.5440E+12
1009	UNC--3	HOG	351	Agriculture	EPP-51-0006	HECTOR MORALES CHICO	1.0800E+10	3.7908E+12
1006	UNC--3	HOG	702	Agriculture	EPP-37-0015	LUIS R. MARTINEZ GONZALEZ	1.0800E+10	7.5816E+12
1030	UNC--3	DAIRY COW	113	Pasture	EPV-37-0003	MIGUEL RAMOSCRUZ	1.0080E+11	1.1390E+13
1006	UNC--3	HOG	144	Agriculture	EPP-37-0012	JOSE GONZALEZ MENDEZ	1.0800E+10	1.5552E+12
1029	UNC--3	HOG	134	Agriculture	EPP-37-0011	RAMON RAMOS VEGA	1.0800E+10	1.4472E+12
1004	UNC--3	DAIRY COW	145	Pasture	EPV-37-0013	PASCUAL MACHADO WHITE	1.0080E+11	1.4616E+13
1006	UNC--3	DAIRY COW	39	Pasture	EPV-37-0019	MARIO ACEVEDO LUCIANO	1.0080E+11	3.9312E+12
1003	UNC--3	DAIRY COW	487	Pasture	EPV-37-0018	CARLOS BENITEZ(EMPRESAS BENIT	1.0080E+11	4.9090E+13
1002	UNC--3	DAIRY COW	89	Pasture	EPV-03-0008	ALBERTO L. TORO LOPEZ	1.0080E+11	8.9712E+12
1009	UNC--3	DAIRY COW	228	Pasture	EPV-51-0004	ALEX TOLEDO (HACIENDA TOLEDO	1.0080E+11	2.2982E+13
1001	UNC--3	DAIRY COW	308	Pasture	EPV-03-0005	LUIS CORDERO MANGUAL	1.0080E+11	3.1046E+13
1028	UNC--3	DAIRY COW	92	Pasture	EPV-37-0030	JORGE I. MORALES RIECHARD	1.0080E+11	9.2736E+12
1029	UNC--3	HOG	21	Agriculture	EPP-37-0006	RAUL JUARBE	1.0800E+10	2.2680E+11

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
1029	UNC--3	HOG	146	Agriculture	EPP-37-0010	JOSE W. PEREZ ACEVEDO	1.0800E+10	1.5768E+12
1003	UNC--3	DAIRY COW	149	Pasture	EPV-51-0006	CARLOS TOLEDO	1.0080E+11	1.5019E+13
7058	PREQ30B	DAIRY COW	114	Pasture	EPV-53-0005	JUAN C. BARRETO	1.0080E+11	1.1491E+13
7057	PREQ30B	DAIRY COW	73	Pasture	EPV-53-0003	EFREN A. ROTGER MELENDEZ	1.0080E+11	7.3584E+12
7058	PREQ30B	DAIRY COW	143	Pasture	EPV-53-0014	Mendoza Benitez Dairy	1.0080E+11	1.4414E+13
7058	PREQ30B	DAIRY COW	185	Pasture	EPV-53-0023	SR. ENEIDO MENDOZA	1.0080E+11	1.8648E+13
7057	PREQ30B	HORSE	5	Pasture	EPO-53-0015	EFREN A. ROTGER	4.2000E+08	2.1000E+09
7056	PRER30A	DAIRY COW	260	Pasture	EPV-53-0025	PANET MENDOZA, INC. (SANTOS P	1.0080E+11	2.6208E+13
7060	PRER30A	HORSE	14	Pasture	EPO-53-0003	HECTOR MALDONADO RODRIGUEZ	4.2000E+08	5.8800E+09
7056	PRER30A	HORSE	43	Pasture	EPO-53-0016	JOSE LUIS MIRANDA CASE╤A (POT	4.2000E+08	1.8060E+10
7055	PRER30A	DAIRY COW	184	Pasture	EPV-53-0027	JOSE RAMOS LAMBOY	1.0080E+11	1.8547E+13
7056	PRER30A	DAIRY COW	22	Pasture	EPV-53-0032	ENEIDO MENDOZA BENITEZ	1.0080E+11	2.2176E+12
7078	PREE31A	DAIRY COW	184	Pasture	EPV-36-0004	EFRAIN AYALA BENITEZ	1.0080E+11	1.8547E+13
7078	PREE31A	DAIRY COW	224	Pasture	EPV-36-0001	VICTOR AYALA BENITEZ	1.0080E+11	2.2579E+13
7078	PREE31A	HOG	4	Agriculture	EPP-36-0008	PEDRO TORRES	1.0800E+10	4.3200E+10
7040	UCW--4	DAIRY COW	115	Pasture	EPV-53-0019	MANUEL G. RAMOS LAMBOY	1.0080E+11	1.1592E+13
7032	UCW--4	HORSE	5	Pasture	EPO-33-0016	CARMEN NIEVES	4.2000E+08	2.1000E+09
7034	UCW--4	HORSE	5	Pasture	EPO-19-0001	ALFONSO BENITEZ PAULO	4.2000E+08	2.1000E+09
7034	UCW--4	HOG	40	Agriculture	EPP-19-0007	EDDIE MEL╔NDEZ MEL╔NDEZ	1.0800E+10	4.3200E+11
7034	UCW--4	DAIRY COW	49	Pasture	EPV-19-0005	JOEL MEL╔NDEZ	1.0080E+11	4.9392E+12
7034	UCW--4	DAIRY COW	62	Pasture	EPV-53-0015	JULIO C. MELENDEZ MELENDEZ	1.0080E+11	6.2496E+12
7040	UCW--4	HORSE	18	Pasture	EPO-53-0013	JOSE CARRASQUILLO	4.2000E+08	7.5600E+09
7040	UCW--4	DAIRY COW	123	Pasture	EPV-53-0022	VAQUERIA HERMANOS RAMOS, INC.	1.0080E+11	1.2398E+13
7038	UCW--4	HOG	35	Agriculture	EPP-53-0001	RENE GONZALEZ ROSA	1.0800E+10	3.7800E+11
7051	PREE29A	DAIRY COW	47	Pasture	EPV-53-0007	ROBERTO RAMIREZ RAMIREZ	1.0080E+11	4.7376E+12
7053	PREE29A	DAIRY COW	161	Pasture	EPV-53-0018	VIOLETA PEREZ	1.0080E+11	1.6229E+13
7006	PREE22A	HORSE	10	Pasture	EPO-27-0003	FELIX DE JESUS MARTINEZ (ANA	4.2000E+08	4.2000E+09
7006	PREE22A	HOG	181	Agriculture	EPP-27-0009	ANA CORDERO RODRIGUEZ / FELIX	1.0800E+10	1.9548E+12
7012	PREE22A	HORSE	21	Pasture	EPO-27-0004	JOSE A. AQUINO GARCIA	4.2000E+08	8.8200E+09
7012	PREE22A	HORSE	7	Pasture	EPO-27-0005	MARIA J. RODRIGUEZ	4.2000E+08	2.9400E+09
7012	PREE22A	DAIRY COW	45	Pasture	EPV-27-0005	JOS╔ A. AQUINO	1.0080E+11	4.5360E+12
7019	UCW--5	HOG	34	Agriculture	EPP-19-0008	JULIO MEDINA COLON	1.0800E+10	3.6720E+11

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
7076	UCW--6	DAIRY COW	334	Pasture	EPV-36-0003	ROBERTO MENDOZA BENITEZ	1.0080E+11	3.3667E+13
7076	UCW--6	DAIRY COW	249	Pasture	EPV-36-0006	EFRAIN AYALA BENITEZ	1.0080E+11	2.5099E+13
10019	PRSE53 A	CHICK EN	87000	Agriculture	EPA-63-0035	OCHOA POULTRY FARM, INC.	1.3600E+08	1.1832E+13
10019	PRSE53 A	HOG	30	Agriculture	EPP-63-0010	LUIS R. COLON SANTOS	1.0800E+10	3.2400E+11
10020	PRSE53 A	HOG	74	Agriculture	EPP-63-0011	MIGUEL FELICIANO TORRES	1.0800E+10	7.9920E+11
10020	PRSE53 A	CHICK EN	9	Agriculture	EPA-63-0022	MYRNA JIM╔NEZ	1.3600E+08	1.2240E+09
10058	PRSR55 A	BEEF COW	3000	Pasture	EPO-63-0002	JOSE I. SADURN═ (HACIENDA LAS	1.0400E+11	3.1200E+14
10045	PRSR54 A--3	CHICK EN	20000	Agriculture	EPA-22-0030	ENRIQUE SANTIAGO	1.3600E+08	2.7200E+12
10049	PRSR54 A--4	CHICK EN	27900	Agriculture	EPA-05-0026	MANUEL GONZALEZ ALVARADO	1.3600E+08	3.7944E+12
10049	PRSR54 A--4	HOG	7	Agriculture	EPP-05-0029	DANIEL RODRIGUEZ	1.0800E+10	7.5600E+10
10106	PRSR57 A2--2	CHICK EN	30000	Agriculture	EPA-22-0043	JOSE L. GIERBOLINI SANTIAGO	1.3600E+08	4.0800E+12
10096	PRSR57 B	CHICK EN	32000	Agriculture	EPA-05-0059	ROBERT MILLER	1.3600E+08	4.3520E+12
10087	PRSR57 B	CHICK EN	22000	Agriculture	EPA-22-0075	FIDENCIO TORRES PADILLA	1.3600E+08	2.9920E+12
10087	PRSR57 B	CHICK EN	30000	Agriculture	EPA-22-0097	RUBEN GIERBOLINI (ANTES ZACAR	1.3600E+08	4.0800E+12
10088	PRSR57 B	BEEF COW	53	Pasture	EPO-22-0007	PEDRO TAPIA DE JESUS	1.0400E+11	5.5120E+12
10092	PRSR57 B	CHICK EN	30000	Agriculture	EPA-22-0019	HIRAM ORTIZ FUENTES	1.3600E+08	4.0800E+12
10100	PRSR57 B	CHICK EN	30000	Agriculture	EPA-05-0042	JOSE A. AYALA ROSADO	1.3600E+08	4.0800E+12
10103	PRSR57 B	CHICK EN	100000	Agriculture	EPA-05-0019	ALEJO CAMACHO TORRES	1.3600E+08	1.3600E+13
10101	PRSR57 B	CHICK EN	24000	Agriculture	EPA-05-0024	PEDRO COTTO COTTO	1.3600E+08	3.2640E+12
10101	PRSR57 B	CHICK EN	36000	Agriculture	EPA-05-0032	LUIS A. RIVERA VIZCARRONDO	1.3600E+08	4.8960E+12
10101	PRSR57 B	CHICK EN	30000	Agriculture	EPA-05-0027	JOSE L. RODRIGUEZ	1.3600E+08	4.0800E+12
10101	PRSR57 B	CHICK EN	30000	Agriculture	EPA-05-0029	ANIBAL CARATINI PEREZ	1.3600E+08	4.0800E+12
10101	PRSR57 B	CHICK EN	36000	Agriculture	EPA-05-0030	EVAGELINE VIZCARRONDO	1.3600E+08	4.8960E+12
10101	PRSR57 B	CHICK EN	13000	Agriculture	EPA-05-0072	MARCELO CUMBA ACEVEDO	1.3600E+08	1.7680E+12
10101	PRSR57 B	HOG	275	Agriculture	EPP-05-0028	RAMON MORALES LABOY	1.0800E+10	2.9700E+12
10100	PRSR57 B	HOG	7	Agriculture	EPP-05-0009	JOSE ANTONIO AYALA ROSADO	1.0800E+10	7.5600E+10
10104	PRSR57 B	HORSE	10	Pasture	EPO-05-0005	Pedro Rosado Cruz	4.2000E+08	4.2000E+09
10089	PRSR57 B	CHICK EN	10000	Agriculture	EPA-22-0109	JORGE L. SANTIAGO ORTIZ	1.3600E+08	1.3600E+12
10103	PRSR57 B	CHICK EN	40000	Agriculture	EPA-22-0010	MANUEL GONZALEZ RODRIGUEZ	1.3600E+08	5.4400E+12
10072	PRSR57 A2--1	HOG	105	Agriculture	EPP-68-0009	Benjamin Torres	1.0800E+10	1.1340E+12
10072	PRSR57 A2--1	HOG	70	Agriculture	EPP-68-0010	BENJAMIN TORRES ALVARADO	1.0800E+10	7.5600E+11
10075	PRSR57 A2--1	CHICK EN	32000	Agriculture	EPA-22-0052	JORGE ZAYAS MATEO	1.3600E+08	4.3520E+12

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
10075	PRSR57 A2--1	CHICK EN	28000	Agriculture	EPA-22-0072	TOMAS HERNANDEZ MELENDEZ	1.3600E+08	3.8080E+12
10075	PRSR57 A2--1	HOG	140	Agriculture	EPP-22-0033	JORGE ZAYAS MATEO	1.0800E+10	1.5120E+12
10075	PRSR57 A2--1	GOAT	10	Agriculture	EPO-22-0006	EXPEDITO ORTIZ	1.2000E+10	1.2000E+11
10075	PRSR57 A2--1	BEEF COW	60	Pasture	EPO-22-0004	EXPEDITO ORTIZ DELGADO	1.0400E+11	6.2400E+12
10083	PRSR57 A2--1	HOG	11	Agriculture	EPP-22-0098	FELIX RAMOS LOPEZ	1.0800E+10	1.1880E+11
5030	PRER14 A1	HORSE	29	Pasture	EPO-16-0005	GUILLERMO PASALAGUA	4.2000E+08	1.2180E+10
5046	PRER14 A1	HORSE	25	Pasture	EPO-71-0023	ROBERTO SANTOS	4.2000E+08	1.0500E+10
5046	PRER14 A1	HORSE	59	Pasture	EPO-71-0014	CARLOS J. HERNANDEZ	4.2000E+08	2.4780E+10
5046	PRER14 A1	HORSE	7	Pasture	EPO-71-0011	ALEXIS FELICIANO	4.2000E+08	2.9400E+09
5045	PREQ14 E	HORSE	35	Pasture	EPO-71-0005	FAUSTINO FIGUEROA DEL VALLE	4.2000E+08	1.4700E+10
5040	PREQ14 E	HORSE	45	Pasture	EPO-71-0027	EUGENIO BETANCOURT RIVERA	4.2000E+08	1.8900E+10
5045	PREQ14 E	HOG	33	Agriculture	EPP-33-0035	RAFAEL ROM┴N GONZ┴LEZ	1.0800E+10	3.5640E+11
5044	PREQ14 E	HOG	57	Agriculture	EPP-71-0048	ANGEL L. CRUZ DELGADO	1.0800E+10	6.1560E+11
5044	PREQ14 E	HORSE	12	Pasture	EPO-71-0008	ROSE MARIE AVILES	4.2000E+08	5.0400E+09
5044	PREQ14 E	RABBIT	54	Agriculture	EPO-71-0004	DOMINGO VARGAS RAMOS	1.2500E+08	6.7500E+09
5040	PREQ14 E	HOG	18	Agriculture	EPP-71-0027	PORFIRIO BETANCOURT	1.0800E+10	1.9440E+11
5040	PREQ14 E	HOG	6	Agriculture	EPP-33-0026	ORLANDO VIERA RUIZ	1.0800E+10	6.4800E+10
5040	PREQ14 E	HOG	85	Agriculture	EPP-33-0021	PEDRO ALEMAN ALEMAN	1.0800E+10	9.1800E+11
5040	PREQ14 E	CHICK EN	10500	Agriculture	EPA-71-0001	ANGEL L. BETANCOURT RUIZ	1.3600E+08	1.4280E+12
5039	PREQ14 E	HORSE	21	Pasture	EPO-71-0024	RAUL APONTE CRUZ	4.2000E+08	8.8200E+09
5036	PREQ14 D	HORSE	10	Pasture	EPO-16-0007	JORGE LUIS MATOS	4.2000E+08	4.2000E+09
5032	PREQ14 D	HORSE	20	Pasture	EPO-16-0012	JUAN BARRETO	4.2000E+08	8.4000E+09
5034	PREQ14 D	HOG	15	Agriculture	EPP-33-0032	SIXTO BORIA CARABALLO	1.0800E+10	1.6200E+11
5035	PREQ14 D	HORSE	9	Pasture	EPO-71-0009	FELIX BARED	4.2000E+08	3.7800E+09
5036	PREQ14 D	CHICK EN	18000	Agriculture	EPA-16-0001	JOSE L. MORALES FRAGOSO	1.3600E+08	2.4480E+12
5036	PREQ14 D	HOG	27	Agriculture	EPP-16-0056	CARLOS DE JESUS	1.0800E+10	2.9160E+11
5032	PREQ14 D	HORSE	60	Pasture	EPO-16-0009	JANET NEGRON PEDROSA	4.2000E+08	2.5200E+10
5013	PRER14 C	HORSE	17	Pasture	EPO-16-0010	ANA MARIA PABON	4.2000E+08	7.1400E+09
5013	PRER14 C	HORSE	6	Pasture	EPO-16-0011	SANTIAGO WALKER	4.2000E+08	2.5200E+09
5003	PRER14 B	HOG	3	Agriculture	EPP-15-0025	CARMEN RODRIGUEZ	1.0800E+10	3.2400E+10
5000	URGL	HOG	353	Agriculture	EPP-45-0001	JESUS GUERRA NAVARRO	1.0800E+10	3.8124E+12
9075	PRSR49 A	BEEF COW	30	Pasture	EPO-30-0006	LOYD SANABRIA HERN┴NDEZ	1.0400E+11	3.1200E+12

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
9075	PRSR49 A	HOG	444	Agriculture	EPP-30-0023	LOYD SANABR═A HERN┴NDEZ	1.0800E+10	4.7952E+12
14140	PRWR7 7D	HOG	50	Agriculture	EPP-12-0001	JOSE IRIZARRY MONTALVO	1.0800E+10	5.4000E+11
14094	PRWR7 7F	HOG	191	Agriculture	EPP-64-0018	WILFREDO PAGAN CORALES	1.0800E+10	2.0628E+12
6001	UCW-- 25	HOG	35	Agriculture	EPP-45-0002	JOSE A. GARCIA	1.0800E+10	3.7800E+11
6015	UCW-- 25	HOG	158	Agriculture	EPP-61-0020	EUSTAQUIO CARRASCO DE JESUS	1.0800E+10	1.7064E+12
6029	PREE16 A	CHICK EN	60000	Agriculture	EPA-61-0001	NESTOR REYES DEL VALLE	1.3600E+08	8.1600E+12
6028	PREE16 A	HORSE	50	Pasture	EPO-61-0005	GREGORY JACKSON WING	4.2000E+08	2.1000E+10
6029	PREE16 A	CHICK EN	22000	Agriculture	EPA-61-0002	CARLOS REYES CALDERON	1.3600E+08	2.9920E+12
6056	PREE19 A	HOG	29	Agriculture	EPP-46-0006	ANGEL L. RODRIGUEZ	1.0800E+10	3.1320E+11
6056	PREE19 A	HOG	48	Agriculture	EPP-46-0013	ANGEL FIGUEROA MONTEZUMA	1.0800E+10	5.1840E+11
6056	PREE19 A	HOG	68	Agriculture	EPP-46-0010	RAQUEL FIGUEROA	1.0800E+10	7.3440E+11
6062	PRER19 A	HORSE	4	Pasture	EPO-46-0032	NEFTAL═ ROSA RIVERA	4.2000E+08	1.6800E+09
6062	PRER19 A	HOG	49	Agriculture	EPP-46-0008	LEONARDO RIVERA RIVERA	1.0800E+10	5.2920E+11
6045	PREE17 A	DAIRY COW	182	Pasture	EPV-46-0005	RAMON DIAZ GUZMAN	1.0080E+11	1.8346E+13
6043	PREE17 A	HORSE	14	Pasture	EPO-46-0022	ALEJANDRO ESTRADA	4.2000E+08	5.8800E+09
6043	PREE17 A	HORSE	2	Pasture	EPO-46-0021	LUIS GONZALEZ	4.2000E+08	8.4000E+08
6043	PREE17 A	HORSE	92	Pasture	EPO-46-0001	RAMON DIAZ GUZMAN	4.2000E+08	3.8640E+10
6043	PREE17 A	HORSE	2	Pasture	EPO-46-0016	JESUS MENDEZ	4.2000E+08	8.4000E+08
6043	PREE17 A	HORSE	5	Pasture	EPO-46-0015	CARLOS PEREZ	4.2000E+08	2.1000E+09
6043	PREE17 A	HORSE	18	Pasture	EPO-46-0019	MOISES ABREU	4.2000E+08	7.5600E+09
6043	PREE17 A	HORSE	17	Pasture	EPO-46-0014	MANUEL DIAZ VARGAS HACIENDA I	4.2000E+08	7.1400E+09
6043	PREE17 A	HORSE	33	Pasture	EPO-46-0018	ROBERTO CAMINO LANDRON	4.2000E+08	1.3860E+10
6043	PREE17 A	HORSE	5	Pasture	EPO-46-0017	FRANCISCO M. TRONCOSO	4.2000E+08	2.1000E+09
6043	PREE17 A	HORSE	5	Pasture	EPO-46-0010	ENRIQUE BRAY	4.2000E+08	2.1000E+09
6042	PREE17 A	HORSE	14	Pasture	EPO-46-0005	JOSE FRANCESCHINI	4.2000E+08	5.8800E+09
6043	PREE17 A	HORSE	4	Pasture	EPO-46-0009	ORLANDO VILLAR	4.2000E+08	1.6800E+09
6043	PREE17 A	HORSE	4	Pasture	EPO-46-0007	CESAR SAINZ	4.2000E+08	1.6800E+09
6006	PREE15 A	HORSE	43	Pasture	EPO-61-0001	EDWIN QUINONES CONDE	4.2000E+08	1.8060E+10
11032	PRSL16 0A	BEEF COW	54	Pasture	EPO-76-0002	ISRAEL RIVERA	1.0400E+11	5.6160E+12
11032	PRSL16 0A	CHICK EN	114000	Agriculture	EPA-76-0002	ISRAEL RIVERA SOTO	1.3600E+08	1.5504E+13
11007	PRSE58 A	HORSE	60	Pasture	EPO-68-0001	POTRERO LUNA, INC. (JUAN LUNA	4.2000E+08	2.5200E+10
11008	PRSE58 A	HOG	20	Agriculture	EPP-22-0019	VICTOR CARDONA SOTO	1.0800E+10	2.1600E+11

Modeled Subbasin	Assessment Unit	Animal	Number of Animals	Assigned landuse	CAFO ID	Facility/Owner	FC (count/ animal/day)	FC Load (count/day)
11078	PRSR64 A--2	HOG	1552	Agriculture	EPP-58-0001	JUAN A. ALVARADO ALVARADO	1.0800E+10	1.6762E+13
11010	UCW--31	HOG	1920	Agriculture	EPP-39-0019	ANGEL LUIS ALVARADO (HAPPY HO	1.0800E+10	2.0736E+13
8009	PREE33 A	HOG	20	Agriculture	EPP-36-0002	ANGEL LUIS DE LEON VAZQUEZ	1.0800E+10	2.1600E+11
8031	PREE35 A	DAIRY COW	516	Pasture	EPV-77-0004	JUAN RAMON GOMEZ FLORES	1.0080E+11	5.2013E+13
8026	PREE35 A	DAIRY COW	155	Pasture	EPV-77-0006	JOS╔ M. D═AZ ROMERO	1.0080E+11	1.5624E+13
8015	PREE34 A	HORSE	75	Pasture	EPO-36-0001	JOS╔ L. BEN═TEZ APONTE	4.2000E+08	3.1500E+10
15009	PRWR7 9A	RABBIT	1017	Agriculture	EPO-50-0002	MARIEL LACOURT PARES	1.2500E+08	1.2713E+11
15009	PRWR7 9A	RABBIT	56	Agriculture	EPO-50-0004	WILLIAM RAMOS	1.2500E+08	7.0000E+09
3031	PRER12 A1	HOG	118	Agriculture	EPP-32-0001	ANGEL L. CAMACHO	1.0800E+10	1.2744E+12
3029	PRER12 A1	HORSE	24	Pasture	EPO-32-0006	TERESA ROSSY	4.2000E+08	1.0080E+10
3035	PRER12 C	HORSE	16	Pasture	EPO-11-0004	OSVALDO CRUZ	4.2000E+08	6.7200E+09
3050	PRELA2	DAIRY COW	526	Pasture	EPV-21-0003	HACIENDA SANTA ELENA. FINCA C	1.0080E+11	5.3021E+13
3014	PRER12 B	HORSE	17	Pasture	EPO-32-0012	DEBORAH PASSALACQUA	4.2000E+08	7.1400E+09
3042	PRER12 A2	CHICK EN	48000	Agriculture	EPA-30-0003	JOSE RODRIGUEZ COLON	1.3600E+08	6.5280E+12
3039	PRER12 A2	HOG	279	Agriculture	EPP-04-0001	GUILLERMO RAMIREZ TORRES	1.0800E+10	3.0132E+12
4000	PREE13 A1	HORSE	53	Pasture	EPO-11-0012	Antonio J Roig Pagan Presiden	4.2000E+08	2.2260E+10
4014	PREE13 A2	HORSE	21	Pasture	EPO-65-0004	UNIDAD MONTADA DE SAN JUAN	4.2000E+08	8.8200E+09
4025	PREE13 A2	HOG	19	Agriculture	EPP-65-0046	JOVITA CONCEPCION GOTAY	1.0800E+10	2.0520E+11
4024	PREE13 A2	HOG	61	Agriculture	EPP-65-0023	MARCOS RODRIGUEZ RIVERA	1.0800E+10	6.5880E+11
4038	PREE13 A3	HORSE	25	Pasture	EPO-45-0003	UNIDAD MONTADA AREA DE CAROLI	4.2000E+08	1.0500E+10
4037	PREE13 A3	HORSE	41	Pasture	EPO-71-0022	MANUEL RIVERA SANTOS	4.2000E+08	1.7220E+10
4027	PREE13 A3	HORSE	64	Pasture	EPO-65-0003	CENTRO ECUESTRE DE P.R.	4.2000E+08	2.6880E+10

APPENDIX F: TMDLS AS DAILY LOADS

NORTH REGION

Source				BASELINE PRNL3A1 (#/day)	**TMDL PRNL3A1 (#/day)**	BASELINE PRNR3A2 (#/day)	**TMDL PRNR3A2 (#/day)**	BASELINE PRNQ3B (#/day)	**TMDL PRNQ3B (#/day)**	BASELINE PRNE5A (#/day)	**TMDL PRNE5A (#/day)**
Nonpoint Sources		Agriculture		2.417E+10	1.759E+08	1.018E+12	5.098E+11	2.007E+07	5.154E+06	3.865E+10	3.582E+06
Nonpoint Sources		Barren		6.157E+05	1.453E+04	3.143E+04	1.428E+03	2.755E+03	7.076E+02	8.930E+05	8.081E+01
Nonpoint Sources		Forest		3.358E+09	1.624E+08	5.902E+09	5.169E+09	9.257E+06	2.377E+06	3.293E+09	2.964E+07
Nonpoint Sources		Pasture		1.239E+13	8.892E+11	2.434E+12	1.017E+12	1.986E+10	5.100E+09	1.711E+13	1.569E+09
Nonpoint Sources		Septics		1.466E+11	0.000E+00	2.110E+11	0.000E+00	6.162E+10	0.000E+00	2.990E+11	0.000E+00
Nonpoint Sources		Urban High Density		1.754E+07	2.137E+03	1.152E+03	7.131E-01	1.348E+02	3.461E+01	3.616E+07	3.254E+03
Nonpoint Sources		Urban Low Density		6.030E+08	4.544E+07	6.026E+08	1.966E+08	9.675E+07	2.485E+07	9.024E+08	8.278E+04
Nonpoint Sources		Wetland		0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	8.039E+06	7.235E+04
Σ LA					**8.896E+11**		**1.532E+12**		**5.132E+09**		**1.603E+09**
Permitted Point Sources	NPDES	ESC AIBONITO BELTRAN	PR0025143	1.891E+07	1.891E+07						
Permitted Point Sources	NPDES	PRASA - GUAJATACA WTP	PR0025721								
Permitted Point Sources	NPDES	PRASA LARES	PR0025879			9.123E+09	9.123E+09				
Permitted Point Sources	NPDES	PRASA LARES WTP	PR0026450			2.360E+09	2.360E+09				
Permitted Point Sources	Urban MS4	Aguadilla--Isabela--San Sebastian, PR	*Isabela*	8.343E+06	7.509E+02			3.890E+08	9.989E+07		
Permitted Point Sources	Urban MS4	Aguadilla--Isabela--San Sebastian, PR	*Lares*	1.335E+07	2.404E+06	2.318E+09	5.917E+08			8.395E+06	7.782E+02
Permitted Point Sources	Urban MS4	Aguadilla--Isabela--San Sebastian, PR	*San Sebastian*	6.999E+08	2.500E+07	4.039E+08	1.394E+08				
Permitted Point Sources	Urban MS4	Aguadilla--Isabela--San Sebastian, PR	*Camuy*							3.032E+08	2.811E+04
Permitted Point Sources	Urban MS4	Arecibo, PR	*Camuy*	4.353E+05	7.841E+04					1.367E+09	1.230E+05
Permitted Point Sources	Urban MS4	Arecibo, PR	*Quebradillas*	2.285E+07	2.057E+03						
Permitted Point Sources	Urban MS4	Arecibo, PR	*Hatillo*							2.154E+09	1.954E+05
Σ WLA					**4.639E+07**		**1.221E+10**		**9.989E+07**		**3.473E+05**
MOS	Margin of Safety				**9.884E+10**		**1.716E+11**		**5.814E+08**		**1.781E+08**
Total Baseline/TMDL				1.257E+13	**9.884E+11**	3.683E+12	**1.716E+12**	8.199E+10	**5.814E+09**	1.746E+13	**1.781E+09**

Source				BASELINE PRNR5A (#/day)	**TMDL PRNR5A (#/day)**	BASELINE UNC--2 (#/day)	**TMDL UNC--2 (#/day)**	BASELINE UNC--3 (#/day)	**TMDL UNC--3 (#/day)**
Nonpoint Sources	**Agriculture**			5.755E+12	3.181E+12	1.625E+11	1.462E+11	1.317E+12	3.267E+11
	Barren			2.653E+04	2.822E+03	8.168E+06	7.351E+06	5.065E+06	1.611E+06
	Forest			1.701E+10	9.009E+09	2.693E+10	2.424E+10	3.575E+09	2.395E+09
	Pasture			1.142E+13	3.033E+12	1.159E+14	1.043E+14	4.508E+13	1.788E+13
	Septics			1.643E+11	0.000E+00	2.514E+12	0.000E+00	1.719E+12	0.000E+00
	Urban High Density			3.221E+06	2.174E+06	2.679E+08	2.411E+08	2.162E+07	1.672E+07
	Urban Low Density			1.297E+09	5.403E+08	3.551E+09	3.196E+09	8.915E+08	4.054E+08
	Wetland			0.000E+00	0.000E+00	1.485E+08	1.337E+08	3.450E+07	3.105E+07
Σ LA					**6.224E+12**		**1.045E+14**		**1.821E+13**
Permitted Point Sources	**NPDES**	**PRASA WTP HATILLO**	**PR0024163**			4.841E+08	4.841E+08		
		PRASA WTP AGUADILLA FILTER PLT	**PR0022918**					1.439E+10	1.439E+10
		PRASA WTP RAMEY PLANT	**PR0024015**					6.536E+08	6.536E+08
	Urban MS4	**Aguadilla--Isabela--San Sebastian, PR**	***Lares***	8.166E+08	2.541E+08	1.857E+09	1.671E+09		
		Aguadilla--Isabela--San Sebastian, PR	***Utuado***	4.964E+08	3.538E+07				
		Aguadilla--Isabela--San Sebastian, PR	***Camuy***			2.893E+08	2.604E+08		
		Aguadilla--Isabela--San Sebastian, PR	***Quebradillas***			9.594E+06	8.634E+06		
		Aguadilla--Isabela--San Sebastian, PR	***San Sebastian***			3.950E+06	3.555E+06	6.001E+07	1.316E+06
		Aguadilla--Isabela--San Sebastian, PR	***Aguadilla***					1.057E+10	4.208E+09
		Aguadilla--Isabela--San Sebastian, PR	***Isabela***					8.338E+09	5.037E+09
		Aguadilla--Isabela--San Sebastian, PR	***Moca***					7.633E+08	1.955E+08
		Arecibo, PR	***Arecibo***			1.108E+10	9.973E+09		
		Arecibo, PR	***Camuy***			6.269E+09	5.642E+09		
		Arecibo, PR	***Hatillo***			1.053E+10	9.480E+09		
		Arecibo, PR	***Quebradillas***			5.484E+09	4.935E+09		
Σ WLA					**2.895E+08**		**3.246E+10**		**2.448E+10**
MOS	**Margin of Safety**				**6.915E+11**		**1.161E+13**		**2.026E+12**
Total Baseline/TMDL				1.736E+13	**6.915E+12**	1.187E+14	**1.161E+14**	4.815E+13	**2.026E+13**

EAST REGION

			BASELINE	TMDL	BASELINE	TMDL	BASELINE	TMDL	BASELINE	TMDL	BASELINE	TMDL	BASELINE	TMDL
Source			PRNR11A (#/day)	**PRNR11A (#/day)**	PRELA2 (#/day)	**PRELA2 (#/day)**	PRER12A1 (#/day)	**PRER12A1 (#/day)**	PRER12A2 (#/day)	**PRER12A2 (#/day)**	PRER12B (#/day)	**PRER12B (#/day)**	PRER12C (#/day)	**PRER12C (#/day)**
Nonpoint Sources	**Agriculture**		3.186E+12	8.721E+11	1.963E+11	1.766E+07	3.801E+13	4.068E+12	1.622E+13	1.192E+12	2.530E+13	4.792E+12	8.778E+12	2.857E+12
	Barren		3.037E+06	1.144E+06	1.156E+06	2.227E+05	1.650E+06	4.105E+04	3.885E+05	1.038E+05	2.566E+06	6.627E+05	3.663E+05	7.735E+04
	Forest		1.601E+09	5.347E+08	1.054E+09	5.514E+08	1.081E+10	1.368E+09	9.075E+09	2.805E+09	9.582E+09	3.311E+09	2.118E+09	9.911E+08
	Pasture		2.245E+11	7.400E+10	2.251E+11	8.226E+10	5.569E+11	5.500E+10	6.165E+11	2.209E+11	4.712E+11	1.295E+11	1.490E+11	4.698E+10
	Septics		3.494E+11	0.000E+00	2.232E+11	0.000E+00	3.593E+11	0.000E+00	5.586E+11	0.000E+00	5.242E+11	0.000E+00	8.882E+10	0.000E+00
	Urban High Density		5.141E+09	1.042E+09	0.000E+00	0.000E+00	1.370E+09	1.995E+07	2.825E+06	1.907E+06	9.782E+08	4.937E+08	2.627E+08	4.069E+07
	Urban Low Density		7.292E+08	1.883E+08	2.899E+08	1.957E+08	4.843E+08	7.092E+04	1.590E+10	4.570E+09	7.705E+08	6.835E+07	5.910E+08	2.402E+08
	Wetland		2.202E+07	1.982E+05	0.000E+00	0.000E+00	2.133E+07	1.920E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Σ LA				***9.479E+11***		***8.303E+10***		***4.124E+12***		***1.420E+12***		***4.925E+12***		***2.906E+12***
Permitted Point Sources	**NPDES**	**PRASA WTP GUAYNABO** / **PR0022438**					1.793E+10	1.793E+10						
	NPDES	**PRASA - CIDRA WTP** / **PR0022543**							1.513E+10	1.513E+09				
	Urban MS4	**San Juan, PR** / ***Bayamon***	9.519E+11	4.034E+11			2.634E+11	1.700E+10	3.042E+09	2.738E+05	3.322E+07	2.990E+03	1.331E+11	4.475E+10
	Urban MS4	**San Juan, PR** / ***Catano***	7.739E+09	1.561E+09			7.100E+07	6.390E+03						
	Urban MS4	**San Juan, PR** / ***Toa Alta***	4.686E+08	2.670E+08										
	Urban MS4	**San Juan, PR** / ***Toa Baja***	7.888E+10	1.663E+10			2.784E+07	2.506E+03						
	Urban MS4	**San Juan, PR** / ***Aguas Buenas***			2.275E+06	2.047E+02			3.179E+10	1.071E+10	6.573E+09	1.003E+09		
	Urban MS4	**San Juan, PR** / ***Caguas***			1.164E+09	1.047E+05								
	Urban MS4	**San Juan, PR** / ***Cidra***			3.862E+10	9.461E+09			4.916E+09	2.186E+09				
	Urban MS4	**San Juan, PR** / ***Guaynabo***					9.842E+10	1.479E+07	1.763E+09	7.762E+07	3.657E+11	1.279E+11		
	Urban MS4	**San Juan, PR** / ***Comerio***							7.519E+07	5.076E+07				
	Urban MS4	**San Juan, PR** / ***San Juan***									1.128E+11	6.883E+10		
Σ WLA				**4.219E+11**		**9.461E+09**		**3.494E+10**		**1.453E+10**		**1.978E+11**		**4.475E+10**
MOS	**Margin of Safety**			**1.522E+11**		**1.028E+10**		**4.622E+11**		**1.594E+11**		**5.692E+11**		**3.278E+11**
Total Baseline/TMDL			4.806E+12	**1.522E+12**	6.857E+11	**1.028E+11**	3.932E+13	**4.622E+12**	1.747E+13	**1.594E+12**	2.679E+13	**5.692E+12**	9.152E+12	**3.278E+12**

				BASELINE	**TMDL**	BASELINE	**TMDL**	BASELINE	**TMDL**	BASELINE	**TMDL**	**BASELINE**	**TMDL**
Source				PREE13A1	**PREE13A1**	PREE13A2	**PREE13A2**	PRER14A1	**PRER14A1**	PRER14B	**PRER14B**	**PRER14C**	**PRER14C**
				(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	**(#/day)**	**(#/day)**
Nonpoint Sources		**Agriculture**		1.869E+10	1.682E+10	3.954E+11	8.594E+10	1.198E+11	6.330E+08	2.340E+12	1.072E+11	1.209E+12	9.990E+10
		Barren		5.708E+07	5.137E+07	1.318E+08	2.983E+06	5.328E+07	7.630E+04	1.012E+07	1.875E+05	2.508E+06	2.086E+05
		Forest		5.784E+08	5.205E+08	1.304E+09	4.088E+08	1.109E+09	2.444E+08	4.541E+09	3.323E+09	2.783E+09	1.719E+09
		Pasture		1.118E+12	1.006E+12	1.676E+12	1.330E+11	2.318E+12	5.814E+09	1.854E+12	5.072E+10	3.112E+12	2.346E+11
		Septics		2.148E+11	0.000E+00	5.884E+11	0.000E+00	3.990E+11	0.000E+00	4.371E+11	0.000E+00	3.151E+11	0.000E+00
		Urban High Density		6.505E+12	5.855E+12	6.245E+12	4.331E+09	7.016E+12	2.226E+10	2.120E+12	8.925E+09	4.141E+11	4.998E+08
		Urban Low Density		0.000E+00	0.000E+00	5.250E+09	4.961E+08	2.090E+10	8.419E+07	1.056E+11	5.742E+09	1.273E+10	1.075E+09
		Wetland		2.776E+08	2.499E+08	5.786E+07	5.207E+05	1.547E+07	1.393E+05	6.364E+05	5.728E+03	2.228E+06	2.005E+04
Σ LA					**6.879E+12**		**2.242E+11**		**2.903E+10**		**1.759E+11**		**3.378E+11**
	NPDES	**ESCUELA SECUNDARIA BARRIO CUBU**	**PR0025241**							8.094E+08	8.094E+07		
		PRASA WTP CANOVANAS	**PR0022420**							NMR	1.210E+10		
		PRASA WTP CUBUY	**PR0022462**							NMR	8.699E+08		
	Urban MS4	**San Juan, PR**	***San Juan***	4.409E+13	3.968E+13	8.3833E+14	4.0946E+11	1.223E+11	1.481E+09				
		San Juan, PR	***Bayamon***	7.729E+13	6.957E+13								
		San Juan, PR	***Catano***	2.191E+14	1.972E+14								
		San Juan, PR	***Guaynabo***	1.259E+14	1.133E+14	1.2814E+14	5.6088E+10						
		San Juan, PR	***Toa Baja***	1.899E+13	1.709E+13								
		San Juan, PR	***Trujillo Alto***			3.267E+13	2.853E+10	3.439E+13	2.834E+11				
		San Juan, PR	***Canovanas***					2.375E+13	2.137E+09	6.528E+12	4.231E+10	2.546E+13	5.032E+10
		San Juan, PR	***Carolina***					1.391E+14	1.252E+10			2.327E+13	5.634E+10
		San Juan, PR	***Rio Grande***							2.586E+11	4.776E+09		
		San Juan, PR	***Juncos***									5.362E+07	3.724E+06
Σ WLA					**4.369E+14**		**4.941E+11**		**2.996E+11**		**6.014E+10**		**1.067E+11**
MOS	**Margin of Safety**				**4.931E+13**		**7.981E+10**		**3.651E+10**		**2.623E+10**		**4.939E+10**
Total Baseline/TMDL				4.933E+14	**4.931E+14**	1.008E+15	**7.981E+11**	2.073E+14	**3.651E+11**	-	**2.623E+11**	5.380E+13	**4.939E+11**

		Source		BASELINE PREQ14D (#/day)	**TMDL PREQ14D (#/day)**	BASELINE PREQ14E (#/day)	**TMDL PREQ14E (#/day)**	BASELINE URGL (#/day)	**TMDL URGL (#/day)**	BASELINE PREE15A (#/day)	**TMDL PREE15A (#/day)**	BASELINE PREE16A (#/day)	**TMDL PREE16A (#/day)**	BASELINE PREE17A (#/day)	**TMDL PREE17A (#/day)**
Nonpoint Sources		**Agriculture**		9.862E+11	8.778E+10	7.234E+11	7.472E+10	4.695E+09	4.225E+05	4.915E+11	1.374E+10	6.307E+11	1.661E+11	9.659E+11	4.451E+10
		Barren		7.323E+06	1.836E+05	2.323E+07	1.793E+05	3.369E+07	3.032E+03	6.153E+06	1.288E+05	2.227E+07	9.550E+06	3.084E+07	9.411E+05
		Forest		1.247E+09	4.784E+08	1.718E+09	1.012E+09	1.859E+08	1.674E+06	5.379E+08	1.248E+07	2.194E+10	1.921E+10	2.719E+10	2.346E+10
		Pasture		1.610E+12	1.679E+11	2.048E+12	1.852E+11	1.619E+12	1.457E+08	1.203E+12	1.734E+10	2.235E+12	5.138E+11	7.691E+12	3.682E+11
		Septics		1.574E+11	0.000E+00	4.567E+11	0.000E+00	1.874E+11	0.000E+00	1.121E+11	0.000E+00	3.157E+11	0.000E+00	1.720E+11	0.000E+00
		Urban High Density		2.250E+10	2.582E+09	6.782E+07	1.086E+06	4.669E+12	4.202E+08	3.889E+11	1.182E+09	1.773E+12	3.788E+10	2.105E+13	2.084E+11
		Urban Low Density		3.334E+10	7.952E+09	3.503E+10	5.804E+09	2.847E+10	2.563E+06	1.654E+09	3.863E+07	9.699E+10	2.650E+10	1.156E+11	6.850E+09
		Wetland		7.956E+05	7.160E+03	0.000E+00	0.000E+00	9.555E+07	8.599E+05	1.592E+05	1.433E+03	7.956E+05	6.081E+04	1.575E+06	1.418E+06
Σ LA					**2.667E+11**		**2.667E+11**		**5.715E+08**		**3.232E+10**		**7.635E+11**		**6.514E+11**
Permitted Point Sources	**NPDES**	**LA GLORIA WARD SCHOOL**	**PR0025577**			4.539E+08	4.539E+07								
		RIMCO INC	**PR0000477**	0.000E+00	0.00E+00										
		PRASA WTP GUZMAN ARRIBA	**PR0022471**									7.640E+08	7.640E+08		
	Urban MS4	**Fajardo, PR**	***Luquillo***											1.586E+11	8.719E+09
		San Juan, PR	***Carolina***	6.143E+12	2.349E+10	1.981E+08	3.173E+06								
		San Juan, PR	***Gurabo***	4.923E+08	1.193E+08	3.238E+10	4.744E+09								
		San Juan, PR	***Trujillo Alto***	1.887E+10	5.420E+09	3.835E+12	4.598E+10								
		San Juan, PR	***Canovanas***					8.127E+13	7.314E+09	1.483E+12	3.123E+10				
		San Juan, PR	***Loiza***					2.008E+13	1.808E+09	7.999E+11	6.982E+08				
		San Juan, PR	***Rio Grande***							2.127E+13	3.964E+10	1.833E+13	1.521E+11	5.025E+12	3.539E+10
Σ WLA					**2.903E+10**		**5.077E+10**		**9.122E+09**		**7.158E+10**		**1.529E+11**		**4.411E+10**
MOS	**Margin of Safety**				**3.286E+10**		**3.527E+10**		**1.077E+09**		**1.154E+10**		**1.018E+11**		**7.728E+10**
Total Baseline/TMDL				8.973E+12	**3.286E+11**	7.132E+12	**3.527E+11**	1.079E+14	**1.077E+10**	2.575E+13	**1.154E+11**	2.340E+13	**1.018E+12**	3.521E+13	**7.728E+11**

				BASELINE	**TMDL**	BASELINE	**TMDL**	BASELINE	**TMDL**	BASELINE	**TMDL**	BASELINE	**TMDL**	BASELINE	**TMDL**
Source				UCW--25	**UCW--25**	UCW--32	**UCW--32**	UCW--33	**UCW--33**	UCW--40	**UCW--40**	PREE34A	**PREE34A**	PREE35A	**PREE35A**
				(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**
Nonpoint Sources		**Agriculture**		1.616E+11	4.635E+10	4.890E+10	6.026E+09	9.319E+09	1.770E+09	0.000E+00	0.000E+00	1.025E+11	2.836E+08	3.751E+12	2.384E+11
		Barren		1.239E+08	5.380E+07	7.042E+07	5.923E+07	4.930E+07	3.767E+07	1.446E+05	1.302E+05	8.348E+07	2.311E+05	3.174E+07	1.451E+06
		Forest		5.386E+09	1.684E+09	8.348E+08	6.524E+08	2.703E+08	1.703E+08	5.974E+06	5.377E+06	2.153E+08	1.938E+08	8.300E+09	5.339E+09
		Pasture		8.499E+12	2.265E+12	9.144E+11	5.718E+11	6.667E+11	2.112E+11	2.119E+10	1.907E+10	1.568E+12	4.341E+09	8.553E+12	7.694E+11
		Septics		5.071E+11	0.000E+00	1.299E+11	0.000E+00	6.684E+10	0.000E+00	2.181E+10	0.000E+00	1.378E+11	0.000E+00	6.666E+11	0.000E+00
		Urban High Density		3.524E+13	1.532E+13	4.989E+12	4.409E+12	2.778E+11	2.226E+11	1.502E+12	1.352E+12	0.000E+00	0.000E+00	4.632E+12	2.881E+10
		Urban Low Density		8.182E+10	1.133E+10	1.356E+10	9.175E+09	2.483E+09	1.383E+09	2.597E+08	2.337E+08	1.458E+09	4.036E+06	1.222E+11	1.455E+10
		Wetland		1.052E+09	8.202E+08	6.040E+06	5.436E+06	1.536E+06	6.551E+05	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.915E+07	1.449E+06
Σ LA					**1.764E+13**		**4.997E+12**		**4.372E+11**		**1.371E+12**		**4.823E+09**		**1.056E+12**
Permitted Point Sources	**NPDES**	**R.J. REYNOLDS TOBACCO (CI)**	**PR0001091**											8.170E+08	8.170E+08
		PRASA WTP GUAYABOTA	**PR0022799**											2.269E+08	2.269E+08
		MARCOS SANCHEZ S.U. SCHOOL	**PR0025402**											1.815E+08	9.077E+07
		PRASA RIO GRANDE ESTATES	**PR0023264**	5.674E+09	5.674E+09										
		PRASA EL YUNQUE FILTRATION PLT	**PR0023931**	1.664E+11	1.664E+10										
		COCO BEACH WTP	**PR0026425**	7.565E+10	7.565E+09										
	Urban MS4	**San Juan, PR**	***Maunabo***			5.341E+12	4.256E+12								
		San Juan, PR	***Yabucoa***			3.383E+12	2.400E+12	1.441E+12	1.115E+12			1.942E+09	5.375E+06	2.204E+13	2.278E+11
		San Juan, PR	***Humacao***					1.149E+13	9.300E+12			3.633E+13	1.006E+11	4.908E+08	6.407E+07
		Fajardo, PR	***Luquillo***	4.942E+13	2.410E+13										
		San Juan, PR	***Canovanas***	4.438E+13	3.994E+13										
		San Juan, PR	***Loiza***	1.358E+14	1.219E+14										
		San Juan, PR	***Rio Grande***	1.531E+14	9.895E+12										
		San Juan, PR	***San Juan***							6.765E+13	6.089E+13				
		San Juan, PR	***San Lorenzo***											7.387E+08	1.075E+08
		San Juan, PR	***Las Piedras***											6.496E+07	1.672E+07
Σ WLA					**1.958E+14**		**6.656E+12**		**1.042E+13**		**6.089E+13**		**1.006E+11**		**2.291E+11**
MOS	**Margin of Safety**				**2.372E+13**		**1.295E+12**		**1.206E+12**		**6.918E+12**		**1.171E+10**		**1.428E+11**
Total Baseline/TMDL				4.274E+14	**2.372E+14**	1.482E+13	**1.295E+13**	1.396E+13	**1.206E+13**	6.920E+13	**6.918E+13**	3.815E+13	**1.171E+11**	3.977E+13	**1.428E+12**

Source				BASELINE PREE33A (#/day)	**TMDL PREE33A (#/day)**	BASELINE PREK35.1 (#/day)	**TMDL PREK35.1 (#/day)**	BASELINE PRER37A (#/day)	**TMDL PRER37A (#/day)**
Nonpoint Sources		**Agriculture**		9.625E+11	6.392E+10	7.755E+11	1.297E+09	8.733E+11	5.315E+10
		Barren		8.079E+07	5.550E+06	2.164E+07	1.032E+04	1.690E+07	3.553E+05
		Forest		3.586E+09	2.795E+09	1.230E+09	1.194E+08	4.185E+09	2.879E+09
		Pasture		5.217E+12	3.016E+11	1.777E+12	2.263E+09	2.077E+12	1.026E+11
		Septics		5.201E+11	0.000E+00	1.669E+11	0.000E+00	4.874E+11	0.000E+00
		Urban High Density		2.720E+12	5.504E+08	1.859E+13	2.236E+10	7.439E+11	2.466E+10
		Urban Low Density		3.961E+10	3.678E+09	2.345E+10	6.237E+07	2.787E+10	2.563E+09
		Wetland		4.097E+05	3.687E+05	1.536E+06	1.382E+04	1.229E+06	1.106E+04
Σ LA					**3.726E+11**		**2.610E+10**		**1.858E+11**
Permitted Point Sources	**NPDES**	**PRASA YABUCOA STP**	**PR0021717**			1.135E+11	1.135E+10		
		PRASA WTP YABUCOA	**PR0022837**			3.631E+08	3.631E+08		
		PRASA MAUNABO	**PR0020656**					7.565E+09	7.565E+09
		PRASA WTP HUMACAO LAS PIEDRAS	**PR0022829**	2.572E+09	2.572E+09				
	Urban MS4	**San Juan, PR**	***Maunabo***			1.444E+07	2.639E+04	2.349E+13	1.697E+11
		San Juan, PR	***Humacao***	1.784E+14	3.167E+11				
		San Juan, PR	***Yabucoa***	6.005E+08	2.720E+07	3.308E+13	3.534E+10	1.444E+07	1.891E+06
		San Juan, PR	***Las Piedras***	4.554E+11	2.469E+10				
Σ WLA					**3.440E+11**		**4.705E+10**		**1.772E+11**
MOS	**Margin of Safety**				**7.962E+10**		**8.127E+09**		**4.034E+10**
Total Baseline/TMDL				1.883E+14	**7.962E+11**	5.452E+13	**8.127E+10**	2.771E+13	**4.034E+11**

SOUTH REGION

Source				BASELINE PRSE53A (#/day)	**TMDL PRSE53A (#/day)**	BASELINE PRSR54A--1 (#/day)	**TMDL PRSR54A--1 (#/day)**	BASELINE PRSR54A--2 (#/day)	**TMDL PRSR54A--2 (#/day)**	BASELINE PRSR54A--3 (#/day)	**TMDL PRSR54A--3 (#/day)**	BASELINE PRSR54A--4 (#/day)	**TMDL PRSR54A--4 (#/day)**	BASELINE UCW--10 (#/day)	**TMDL UCW--10 (#/day)**
Nonpoint Sources	**Agriculture**			1.696E+11	3.052E+08	1.182E+11	6.189E+10	4.361E+10	1.721E+10	3.196E+11	1.885E+11	4.667E+11	3.150E+11	8.063E+10	7.155E+10
	Barren			1.203E+05	2.907E+04	2.478E+05	8.817E+04	1.791E+05	2.026E+04	7.216E+04	4.510E+04	1.064E+05	7.145E+04	1.009E+05	6.938E+04
	Forest			8.078E+08	4.907E+08	2.459E+09	1.811E+09	3.092E+09	1.138E+09	3.307E+09	2.028E+09	6.242E+09	5.294E+09	1.735E+08	1.562E+08
	Pasture			3.786E+12	1.305E+12	6.509E+12	2.749E+12	2.504E+12	3.714E+11	8.973E+11	4.648E+11	2.590E+12	1.610E+12	2.039E+12	1.607E+12
	Septics			1.428E+11	0.000E+00	2.644E+11	0.000E+00	2.152E+11	0.000E+00	1.348E+11	0.000E+00	1.854E+11	0.000E+00	6.457E+10	0.000E+00
	Urban High Density			9.910E+07	2.434E+07	4.562E+08	2.708E+07	8.519E+07	4.624E+05	0.000E+00	0.000E+00	3.923E+07	2.648E+07	8.983E+07	7.582E+07
	Urban Low Density			3.102E+08	1.067E+08	4.337E+08	1.081E+08	3.309E+08	2.718E+07	7.262E+07	4.432E+07	2.966E+08	1.793E+08	8.187E+07	5.869E+07
	Wetland			8.436E+07	1.866E+07	1.239E+08	1.813E+07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.914E+08	1.723E+08
Σ LA					**1.306E+12**		**2.813E+12**		**3.898E+11**		**6.553E+11**		**1.931E+12**		**1.679E+12**
Permitted Point Sources	**NPDES**			-	-	-	-	-	-	-	-	-	-	-	-
	Urban MS4	**San Juan, PR**	***Cayey***					4.862E+06	1.597E+03	4.752E+06	1.762E+06	6.570E+07	4.435E+07		
		San Juan, PR	***Salinas***					4.357E+07	1.353E+05			2.194E+08	1.480E+08		
		San Juan, PR	***Cayey***												
		San Juan, PR	***Cayey***												
		Guayama, PR	***Salinas***	3.023E+08	8.266E+06									1.998E+07	1.799E+07
		Guayama, PR	***Guayama***											2.707E+07	2.421E+07
Σ WLA					**8.266E+06**		**0.000E+00**		**1.369E+05**		**1.762E+06**		**1.924E+08**		**4.220E+07**
MOS	**Margin of Safety**				**1.451E+11**		**3.125E+11**		**4.331E+10**		**7.282E+10**		**2.145E+11**		**1.866E+11**
Total Baseline/TMDL				4.100E+12	**1.451E+12**	6.895E+12	**3.125E+12**	2.767E+12	**4.331E+11**	1.355E+12	**7.282E+11**	3.249E+12	**2.145E+12**	2.185E+12	**1.866E+12**

				BASELINE	TMDL	BASELINE	TMDL	BASELINE	TMDL	BASELINE	TMDL	BASELINE	TMDL	BASELINE	TMDL
Source				PRSE60A	**PRSE60A**	PRSL160A	**PRSL160A**	PRSL260A	**PRSL260A**	PRSR61A	**PRSR61A**	PRSE61A	**PRSE61A**	UCW--13	**UCW--13**
				(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**
Nonpoint Sources		**Agriculture**		6.944E+11	7.115E+09	5.860E+12	3.955E+12	7.210E+12	2.933E+12	6.749E+12	1.110E+12	5.153E+12	1.467E+12	0.000E+00	0.000E+00
		Barren		1.020E+06	1.516E+05	2.123E+06	1.437E+06	1.679E+06	8.958E+05	1.030E+06	1.549E+05	1.333E+06	3.555E+05	3.619E+06	2.104E+03
		Forest		3.093E+09	4.902E+08	1.582E+10	1.423E+10	3.164E+10	1.544E+10	3.400E+10	5.372E+09	5.231E+10	1.837E+10	2.349E+07	2.114E+07
		Pasture		2.372E+12	4.278E+11	1.459E+13	9.930E+12	2.493E+13	1.367E+13	7.184E+12	1.103E+12	6.640E+12	1.480E+12	1.170E+11	6.685E+09
		Septics		3.852E+11	0.000E+00	5.282E+11	0.000E+00	4.468E+11	0.000E+00	2.940E+11	0.000E+00	4.419E+11	0.000E+00	3.409E+10	0.000E+00
		Urban High Density		3.083E+07	4.080E+06	4.114E+06	2.809E+06	1.127E+08	4.808E+07	0.000E+00	0.000E+00	2.034E+07	1.202E+07	0.000E+00	0.000E+00
		Urban Low Density		1.913E+08	3.100E+07	3.272E+08	2.214E+08	1.495E+09	8.640E+08	5.214E+08	6.728E+07	5.333E+08	9.848E+07	1.137E+08	2.452E+07
		Wetland		4.291E+06	3.862E+04	2.993E+07	2.693E+07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	1.106E+08	6.338E+06	0.000E+00	0.000E+00
Σ LA					**4.354E+11**		**1.390E+13**		**1.662E+13**		**2.219E+12**		**2.966E+12**		**6.731E+09**
Permitted Point Sources	**NPDES**	**PRASA REAL ANON FILTER PLANT**	**PR0025852**									3.268E+08	3.268E+08		
	Urban MS4	**Juana Diaz, PR**	***Juana Diaz***	1.284E+09	6.840E+07	3.929E+07	3.536E+07			2.644E+08	4.968E+05	1.243E+07	1.118E+07		
		Juana Diaz, PR	***Villalba***	5.171E+07	2.825E+04	2.403E+09	1.661E+09	1.859E+08	1.479E+08	1.630E+05	2.781E+04				
		Ponce, PR	***Juana Diaz***	6.400E+07	5.760E+03							5.859E+07	5.273E+07		
		Ponce, PR	***Ponce***	1.009E+07	9.083E+02							1.270E+09	2.977E+08		
		San Juan, PR	***Coamo***					1.981E+08	7.927E+07						
		San Juan, PR	***Orocovis***					1.074E+07	4.299E+06						
		Guayama, PR	***Arroyo***											2.006E+13	1.166E+10
		Guayama, PR	***Guayama***											2.061E+12	1.344E+09
Σ WLA					**6.843E+07**		**1.696E+09**		**2.314E+08**		**5.246E+05**		**2.966E+12**		**1.300E+10**
MOS	**Margin of Safety**				**4.839E+10**		**1.545E+12**		**1.847E+12**		**2.465E+11**		**3.296E+11**		**2.193E+09**
Total Baseline/TMDL				3.456E+12	**4.839E+11**	2.100E+13	1.545E+13	3.262E+13	**1.847E+13**	1.426E+13	**2.465E+12**	1.229E+13	**3.296E+12**	2.227E+13	**2.193E+10**

Source				BASELINE UCW--39 (#/day)	**TMDL UCW--39 (#/day)**	BASELINE PRSR68A (#/day)	**TMDL PRSR68A (#/day)**	BASELINE PRSL68A (#/day)	**TMDL PRSL68A (#/day)**	BASELINE PRSE69A (#/day)	**TMDL PRSE69A (#/day)**	BASELINE PRSR69A1 (#/day)	**TMDL PRSR69A1 (#/day)**	BASELINE UVL-E (#/day)	**TMDL UVL-E (#/day)**
Nonpoint Sources		**Agriculture**		6.171E+11	3.422E+11	6.202E+12	2.052E+12	1.013E+13	9.116E+12	1.426E+10	6.714E+09	8.596E+10	4.989E+10	1.354E+11	1.071E+11
		Barren		1.187E+05	9.031E+04	6.927E+05	1.418E+05	2.719E+05	2.448E+05	7.160E+03	3.301E+03	8.070E+04	4.983E+04	9.751E+04	2.235E+04
		Forest		7.210E+08	3.799E+08	1.742E+10	1.209E+10	1.904E+10	1.714E+10	6.415E+08	5.774E+08	1.742E+09	1.568E+09	6.748E+09	5.728E+09
		Pasture		1.581E+11	8.831E+10	5.931E+12	2.134E+12	6.464E+12	5.817E+12	1.698E+10	9.694E+09	7.086E+10	4.567E+10	1.165E+12	7.566E+11
		Septics		6.743E+10	0.000E+00	6.124E+11	0.000E+00	3.756E+11	0.000E+00	7.584E+10	0.000E+00	2.077E+11	0.000E+00	9.151E+11	0.000E+00
		Urban High Density		1.267E+07	1.111E+07	1.028E+07	6.337E+05	0.000E+00	0.000E+00	3.575E+07	1.647E+07	2.646E+06	1.575E+06	3.942E+08	3.177E+08
		Urban Low Density		4.987E+06	3.672E+06	2.750E+08	1.304E+08	4.682E+08	4.214E+08	2.843E+07	1.461E+07	1.132E+08	7.558E+07	6.032E+08	3.650E+08
		Wetland		6.997E+07	4.406E+07	4.777E+06	1.913E+06	0.000E+00	0.000E+00	8.979E+06	8.081E+06	6.864E+05	6.177E+05	1.255E+08	1.128E+08
Σ LA					**4.310E+11**		**4.198E+12**		**1.495E+13**		**1.702E+10**		**9.721E+10**		**8.702E+11**
Permitted Point Sources	**NPDES**	**PRASA YAUCO STP**	**PR0021661**			1.565E+11	1.565E+10								
		PRASA LAJAS	**PR0020575**											9.077E+09	9.077E+09
	Urban MS4	**Yauco, PR**	***Guayanilla***			1.471E+07	1.324E+03								
		Yauco, PR	***Yauco***			2.459E+09	1.672E+08	3.282E+07	2.953E+07			1.232E+09	7.879E+08		
		Yauco, PR	***Guanica***							5.289E+08	2.446E+08	3.661E+08	2.312E+08	2.853E+08	2.550E+08
		Yauco, PR	***Sabana Grande***									1.563E+07	9.012E+06	3.222E+08	2.184E+07
		San German--Cabo Rojo--Sabana Grande, PR	***Sabana Grande***									1.960E+07	1.323E+07	8.751E+08	6.354E+07
		Yauco, PR	***Lajas***											3.533E+07	2.822E+07
		San German--Cabo Rojo--Sabana Grande, PR	***Lajas***											1.820E+09	4.941E+08
		San German--Cabo Rojo--Sabana Grande, PR	***San German***											6.454E+07	1.989E+05
Σ WLA					**0.000E+00**		**1.581E+10**		**2.953E+07**		**2.446E+08**		**1.041E+09**		**9.940E+09**
MOS	**Margin of Safety**				**4.789E+10**		**4.682E+11**		**1.661E+12**		**1.919E+09**		**1.092E+10**		**9.779E+10**
Total Baseline/TMDL				8.435E+11	**4.789E+11**	1.292E+13	**4.682E+12**	1.699E+13	**1.661E+13**	1.083E+11	**1.919E+10**	3.680E+11	**1.092E+11**	2.236E+12	**9.779E+11**

Source				BASELINE PRSR67A (#/day)	**TMDL PRSR67A (#/day)**	BASELINE UVL-W (#/day)	**TMDL UVL-W (#/day)**	BASELINE PRSL69A (#/day)	**TMDL PRSL69A (#/day)**	BASELINE UCW--7 (#/day)	**TMDL UCW--7 (#/day)**	BASELINE UCW--35 (#/day)	**TMDL UCW--35 (#/day)**
Nonpoint Sources		**Agriculture**		3.677E+12	1.173E+12	4.086E+07	3.678E+07	2.494E+10	1.684E+10	7.843E+12	3.799E+12	0.000E+00	0.000E+00
		Barren		3.012E+05	1.483E+05	2.481E+05	1.711E+05	4.241E+04	2.896E+04	7.868E+05	6.239E+05	4.169E+06	2.782E+06
		Forest		1.668E+10	5.462E+09	2.204E+09	1.984E+09	3.907E+09	3.516E+09	8.957E+08	8.062E+08	6.246E+09	5.622E+09
		Pasture		6.411E+12	1.612E+12	5.555E+11	3.577E+11	4.932E+10	3.548E+10	2.980E+12	1.826E+12	1.608E+12	7.593E+11
		Septics		5.039E+11	0.000E+00	3.854E+11	0.000E+00	1.822E+11	0.000E+00	2.538E+11	0.000E+00	1.962E+11	0.000E+00
		Urban High Density		3.425E+07	2.707E+06	1.745E+08	1.570E+08	3.388E+06	2.287E+06	1.262E+09	1.004E+09	2.834E+08	8.357E+07
		Urban Low Density		3.792E+08	1.464E+08	2.201E+08	1.981E+08	1.399E+08	1.044E+08	3.237E+08	1.873E+08	1.197E+08	5.485E+07
		Wetland		1.645E+08	1.091E+07	5.468E+08	4.921E+08	0.000E+00	0.000E+00	1.428E+09	1.285E+09	8.903E+08	8.013E+08
Σ LA					**2.790E+12**		**3.606E+11**		**5.594E+10**		**5.628E+12**		**7.659E+11**
Permitted Point Sources	**NPDES**	**PRASA GUAYANILLA**	**PR0020494**	4.691E+09	4.691E+09								
		PRASA JAGUA-PASTO FILTER PLNT	**PR0024678**	5.446E+08	5.446E+08								
	Urban MS4	**San German--Cabo Rojo--Sabana Grande, PR**	***Cabo Rojo***			4.100E+08	2.100E+08						
		San German--Cabo Rojo--Sabana Grande, PR	***Lajas***			3.955E+08	9.317E+07						
		San German--Cabo Rojo--Sabana Grande, PR	***San German***			7.182E+07	2.146E+05						
		Guayama, PR	***Salinas***							1.555E+08	1.400E+08		
		Ponce, PR	***Penuelas***									2.131E+08	5.473E+06
		Ponce, PR	***Ponce***									1.276E+09	1.088E+09
		Yauco, PR	***Yauco***	6.937E+07	3.018E+07			2.742E+08	1.943E+08				
		Yauco, PR	***Guayanilla***	1.334E+09	4.109E+08								
Σ WLA					**5.676E+09**		**3.034E+08**		**1.943E+08**		**1.400E+08**		**1.094E+09**
MOS	**Margin of Safety**				**3.106E+11**		**4.010E+10**		**6.237E+09**		**6.254E+11**		**8.522E+10**
Total Baseline/TMDL				**1.062E+13**	**3.106E+12**	**9.449E+11**	**4.010E+11**	**2.608E+11**	**6.237E+10**	**1.108E+13**	**6.254E+12**	**1.813E+12**	**8.522E+11**

WEST REGION

Source				BASELINE	**TMDL**	BASELINE	**TMDL**	BASELINE	**TMDL**	BASELINE	TMDL	BASELINE	**TMDL**
				PRWR77A	**PRWR77A**	PRWR77B	**PRWR77B**	PRWR77C	**PRWR77C**	PRWR77D	PRWR77D	PRWR77E	**PRWR77E**
				(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	**(#/day)**	(#/day)	(#/day)	(#/day)	**(#/day)**
Nonpoint Sources	**Agriculture**			1.058E+10	7.142E+09	2.715E+09	1.832E+09	9.137E+10	1.974E+10	0.000E+00	0.000E+00	1.498E+11	1.011E+11
	Barren			5.193E+05	2.190E+05	7.626E+04	5.147E+04	4.776E+04	2.297E+04	1.559E+05	1.052E+05	1.395E+05	9.419E+04
	Forest			8.695E+09	7.826E+09	1.607E+09	1.446E+09	8.516E+09	7.664E+09	2.755E+09	2.479E+09	3.406E+10	3.065E+10
	Pasture			8.699E+11	3.708E+11	7.220E+10	4.873E+10	1.075E+11	2.858E+10	4.256E+11	2.873E+11	5.831E+11	3.936E+11
	Septics			5.569E+11	0.000E+00	9.823E+10	0.000E+00	3.484E+11	0.000E+00	3.870E+11	0.000E+00	2.404E+11	0.000E+00
	Urban High Density			1.717E+08	6.057E+07	4.631E+07	3.126E+07	3.063E+07	7.399E+06	1.654E+08	1.117E+08	0.000E+00	0.000E+00
	Urban Low Density			4.054E+08	1.713E+08	2.166E+07	1.462E+07	4.369E+08	6.891E+07	2.231E+08	1.506E+08	8.288E+08	5.594E+08
	Wetland			4.626E+07	4.164E+07	0.000E+00	0.000E+00	0.000E+00	0.000E+00	4.036E+08	3.632E+08	0.000E+00	0.000E+00
Σ LA					**3.860E+11**		**5.206E+10**		**5.606E+10**		2.904E+11		**5.259E+11**
Permitted Point Sources	**NPDES**	**PRASA SAN GERMAN**	**PR0020818**	6.052E+10	6.052E+10								
		PRASA WTP SAN GERMAN	**PR0022977**	NMR	1.233E+09								
		PRASA WTP SABANA GRANDE	**PR0024007**	NMR	5.446E+08								
		PRASA SABANA GRANDE STP	**PR0025542**	7.565E+09	7.565E+09								
		PRASA MARICAO	**PR0020648**					1.324E+10	1.324E+09				
		PRASA WTP MARICAO FILTER PLANT	**PR0022969**					1.797E+10	1.797E+09				
	Urban MS4	**San German--Cabo Rojo--Sabana Grande, PR**	***Cabo Rojo***										
		Mayaguez, PR	***Hormigueros***	1.793E+09	1.118E+09	2.568E+08	1.733E+08	2.820E+08	9.233E+07				
		Mayaguez, PR	***Mayaguez***	3.119E+06	2.067E+05	1.523E+09	1.028E+09	9.507E+07	2.315E+07				
		Mayaguez, PR	***San German***	1.133E+08	4.326E+07			1.518E+08	7.211E+07			5.968E+08	4.029E+08
		San German--Cabo Rojo--Sabana Grande, PR	***Cabo Rojo***	9.404E+07	6.274E+07								
		San German--Cabo Rojo--Sabana Grande, PR	***Sabana Grande***	2.038E+09	4.262E+08								
		San German--Cabo Rojo--Sabana Grande, PR	***San German***	3.173E+09	1.217E+09					9.353E+08	6.313E+08	5.403E+08	3.647E+08
		San German--Cabo Rojo--Sabana Grande, PR	***Cabo Rojo***							2.296E+09	1.550E+09		
		San German--Cabo Rojo--Sabana Grande, PR	***Lajas***							1.514E+06	1.022E+06		
Σ WLA					**7.273E+10**		**1.201E+09**		**3.308E+09**		2.182E+09		**7.676E+08**
MOS	**Margin of Safety**				**5.097E+10**		**5.918E+09**		**6.596E+09**		3.251E+10		**5.852E+10**
Total Baseline/TMDL				-	**5.097E+11**	1.766E+11	**5.918E+10**	5.880E+11	**6.596E+10**	8.193E+11	3.251E+11	1.009E+12	**5.852E+11**

Source				BASELINE PRWR77F (#/day)	**TMDL PRWR77F (#/day)**	BASELINE PRWR77G (#/day)	**TMDL PRWR77G (#/day)**	BASELINE PRWR77H (#/day)	**TMDL PRWR77H (#/day)**	BASELINE PRWR77I (#/day)	**TMDL PRWR77I (#/day)**
Nonpoint Sources	**Agriculture**			9.094E+09	6.139E+09	4.547E+09	3.069E+09	4.028E+10	1.665E+10	4.011E+10	2.708E+10
	Barren			2.189E+05	1.449E+05	9.245E+04	6.240E+04	7.055E+04	1.954E+04	3.064E+05	2.066E+05
	Forest			2.222E+10	2.000E+10	1.208E+10	1.087E+10	1.113E+10	1.001E+10	8.210E+09	7.389E+09
	Pasture			4.933E+11	2.304E+11	2.605E+11	1.759E+11	1.218E+11	3.651E+10	8.684E+10	5.699E+10
	Septics			1.420E+11	0.000E+00	7.418E+10	0.000E+00	1.156E+11	0.000E+00	1.488E+11	0.000E+00
	Urban High Density			2.156E+05	1.719E+04	0.000E+00	0.000E+00	1.918E+06	1.226E+05	4.387E+06	2.180E+06
	Urban Low Density			2.542E+08	1.419E+08	1.640E+08	1.107E+08	2.285E+08	8.597E+07	2.792E+08	1.872E+08
	Wetland			0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
Σ LA					**2.566E+11**		**1.899E+11**		**6.326E+10**		**9.165E+10**
Permitted Point Sources	**NPDES**	**PRASA - CAIN ALTO WTP**	**PR0026204**	2.345E+08	2.345E+08						
		PRASA - LA MAQUINA WTP	**PR0026131**					1.634E+08	1.634E+08		
		PRASA WTP MAYAGUEZ FILTER PLT	**PR0022900**								
	Urban MS4	**Mayaguez, PR**	***Mayaguez***								
		San German--Cabo Rojo--Sabana Grande, PR	***Sabana Grande***			4.514E+05	3.047E+05	7.506E+08	2.997E+08	6.168E+08	3.477E+08
		San German--Cabo Rojo--Sabana Grande, PR	***San German***	1.305E+09	5.429E+08	3.176E+08	2.144E+08	9.722E+07	3.726E+07		
		San German--Cabo Rojo--Sabana Grande, PR	***Cabo Rojo***								
Σ WLA					**7.774E+08**		**2.147E+08**		**5.004E+08**		**3.477E+08**
MOS	**Margin of Safety**				**2.860E+10**		**2.113E+10**		**7.085E+09**		**1.022E+10**
Total Baseline/TMDL				6.684E+11	**2.860E+11**	3.518E+11	**2.113E+11**	2.901E+11	**7.085E+10**	2.848E+11	**1.022E+11**