PUERTO RICO ENVIRONMENTAL QUALITY BOARD
SAN JUAN, PUERTO RICO

TOTAL MAXIMUM DAILY LOADS (TMDL)
RÍO GRANDE DE LOIZA WATERSHED

FECAL COLIFORM, COPPER,
BIOCHEMICAL OXYGEN DEMAND/AMMONIA

Proposed: January, 2007
Established: August, 2007
Approved by EPA:
Adopted by EQB

TOTAL MAXIMUM DAILY LOADS (TMDL)
RÍO GRANDE DE LOIZA WATERSHED

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

Section | Title | Page

List of Appendices

I. EXECUTIVE SUMMARY

1.1 General

In accordance with Section 305(b) of the Federal Clean Water Act (the Act), the Commonwealth of Puerto Rico developed the "2004 305(b)/303(d) Integrated Report" including Puerto Rico Water Quality Inventory and List of Impaired Waters. This report, issued in final version in May 2004, forms the basis of the analyses and Total Maximum Daily Loads (TMDLs) presented within this document.

Section 303(d) of the Act requires the Commonwealth of Puerto Rico to identify those water bodies which, after application of the technology-based effluent limitations required by the Act, will not achieve water quality standards. These water bodies are then identified as being "water quality limited." Section 303(d) then requires the establishment and EPA approval of TMDLs which, upon implementation, will achieve applicable water quality standards.

The TMDL for the pollutant represents the water body's loading capacity for the particular pollutant. It is the sum of all the point source waste load allocations (WLA) and all the non-point source load allocations (LA) with a margin of safety (MOS) included to account for uncertainties.

In some cases, the determination of the need to prepare a particular TMDL was supplemented and added to based upon further analyses that indicated additional non-attainment of WQS. In other cases, the need to prepare a particular TMDL was tempered by and reduced as a result of analyses of the quality and nature of existing water quality and discharger data. These analyses and modifications are summarized in Section IV of this report.

The listing of the impaired waters by designated Assessment Unit (AU), as well as identification of the Parameter(s) of Interest (POIs) [*] for which TMDLs are recommended and support documents have been included, is presented in Table I-1.

---

[*] The terms Parameters of Interest (POI) and Pollutants of Concern (POC) are used interchangeably within this report.

Table I-1
IMPAIRED WATERS FROM THE 2004 303(d) LIST

Water Body	Assessment Unit	Water Body Size	POI	Water Quality Classification	Ranking
Rio Grande de Loiza	PRER0104b_00	12.3 miles	Fecal Coliform, Arsenic, Cyanide	SD	High
Rio Gurabo	PRER0108b_00	18.6 miles	Fecal Coliform, Arsenic, Copper, Low DO	SD	High
Rio Gurabo	PRER0108h_02	6.9 miles	Fecal Coliform	SD	High
Rio Bairoa	PRER0109b_00	7.3 miles	Fecal Coliform, Arsenic, Copper, Cyanide	SD	High
Rio Grande de Loiza	PRER0110b_00	16.2 miles	Fecal Coliform, Arsenic, Copper, Lead, Ammonia, Low DO, Cyanide	SD	High
Rio Grande de Loiza	PRER0110e_00	29 miles	Fecal Coliform	SD	High
Rio Grande de Loiza	PRER0110f_02	12.3 miles	Fecal Coliform	SD	High
Rio Grande de Loiza	PRER0110h_02	11.9 miles	Fecal Coliform, Low DO, Ammonia	SD	High
Rio Grande de Loiza	PRER0110i_03	12.3 miles	Fecal Coliform	SD	High
Lake Loiza	PREL0105_00	713 acres	Low DO	SD	Low

This report recommends a phased approach to establishing TMDLs in the Rio Grande de Loiza Watershed. The EPA guidance documents concerning the TMDL process recognizes that some receiving waters have serious and complex water quality problems. For these waters, pollutant reduction strategies can be implemented in a phased approach. This is addressed in "Guidance for Water Quality Based Decisions: The TMDL Process; EPA/4-91-001; April 1991," and is specifically stated in, "Appendix F, Procedure 3 of Final Water Quality Guidance for the Great Lakes System" (Federal Register, March 23, 1995, Part III, Environmental Protection Agency, 40CFR9, 122, 123, 131, 132).

"TMDLs shall, at a minimum, be established in accordance with the listing and priority seeing process established in section 303(d) of the CWA and at 40CFR130.7. Where water quality standards cannot be attained immediately, TMDLs must reflect reasonable assurances that water quality standards will be attained in a reasonable period of time. Some TMDLs may be based on attaining water quality standards over a period of time,

with specific controls on individual sources being implemented in stages. Determining the reasonable period of time in which water quality standards will be met is a case-specific determination considering a number of factors, including, but not limited to, recurring water characteristics, persistence, behavior and ubiquity of pollutants of concern; type of remediation activities necessary; available regulatory and non-regulatory controls; and individual State or Tribal requirements for attainment of water quality standards."

1.2 TMDLs Included

The TMDLs recommended and included in this report include the following Parameters of Interest (POI) at a variety of locations (assessment units), which are specified in the body of the report.

1.2.1 Fecal Coliform

Bacterial contamination causes the contravention of water quality standards in nine (9) of the watershed's Assessment Units (AU). Point and non-point sources of pollution have been identified as contributing to the problem in each of the AUs. For each AU, management options aimed at correcting the problem have been identified and detailed recommendations for implementation have been provided.

1.2.2 Copper

Copper has been identified as exceeding the water quality standards in three (3) Assessment Units. Point and non-point sources of pollution have been identified as contributing to the problem in each AU. For each AU, management options aimed at correcting the problem have been identified and detailed recommendations for implementation have been provided.

1.2.3 Ammonia

Ammonia has been identified as exceeding the water quality standards in two Assessment Units (see Dissolved Oxygen for elsewhere where it may contribute to water quality violations). Point and non-point sources of pollution have been identified as contributing to the problem in each AU. Management options and detailed recommendations for implementation have been provided.

1.2.4 BOD-NOD Dissolved Oxygen (Streams)

Dissolved Oxygen has been identified as below the 5.0 mg/l standard in four Assessment Units. This is caused by a combination of factors including Biochemical Oxygen Demand (BOD) and Nitrogenous Oxygen Demand (NOD). Furthermore, impoundments within these streams may, during low flow periods, experience dissolved oxygen deficits due to over fertilization. Assessments were performed in each of the AUs determining allowable oxygen demand, distributing it between BOD and NOD and providing detailed implantation recommendations for contributory point and non-point sources. Analysis of over fertilization is beyond the capability of this report and may be appropriate for future study (see Phase II recommendations).

II. INTRODUCTION

Several water bodies in the Río Grande de Loíza watershed, as listed in the preceding section, have been identified as being impaired. This report proposes and provides support documents for 23 TMDLs, which establish allowable loads of the applicable POI(s) to the identified assessment units. This TMDL support document includes management approaches or restoration plans to reduce loadings from various sources in order to attain applicable water quality standards. Separate TMDL evaluations are presented for each POI and Au in the following sections of this report.

This report provides technical bases and recommendations in support of the establishment of TMDLs. A TMDL will be considered as "proposed" when the Board publishes the TMDL Report as proposed. A TMDL is considered to be "established" when the Board finalizes the TMDL Report after considering comments received during the public period formally submits it to EPA for review. A TMDL is considered as "approved"when the TMDL is approved by EPA. The TMDL is considered as "adopted" when the "approved" TMDL is adopted by the Board as an amendment to its Water Quality Management Plan.

III. BACKGROUND

A TMDL represents the assimilative or carrying capacity of a water body, taking into consideration point and non-point sources of pollutant of concern, natural background conditions and surface water withdrawals. A TMDL quantifies the amount of a pollutant a water body can assimilate without violating the water quality standards and then allocates that load capacity to known point sources in the form of waste load allocations (WLA), non-point sources in the form of load allocations (LA), and some set aside as a margin of safety (MOS). A TMDL identifies all the contributors to the water quality problem and sets load reductions for the pollutant of concern ro eliminate it.

The Clean Water Act under Section 303(d) requires the identification of "Impaired Waters"where specifically designated uses are not fully supported by existing water quality. For these waters, the establishments of TMDLs are required. To carry out this mandate, the Board prepared a list of impaired waters. Section 305(b) of the Act also reuires a periodic assessment and report on the overall quality of all waters. These two requirements form the basis of the Integrated Report upon which this report has been built.

EPA guidance date July 21, 2003, describes the statutory and regulatory requirements for approval of TMDLs. This report provides the following components, which address these needs:

- Identification of water bodies, ranking, pollutant(s) of concern and pollutant sources.
- Description of applicable water quality standards and numeric water quality targets.
- Loading Capacity.
- Waste Load Allocations.
- Load Allocations.
- Margin of safety.
- Seasonal variations as appropiate.
- Reasonable assurance.
- Monitoring plan to track TMDL effectiveness.
- Phase II program recommendations
- Implementation recommendations.

IV. ANALYSIS OF WATERSHED MODELING, LAND USE, WATER QUALITY PROBLEMS AND POLLUTANT SOURCES

1.0 WATERSHED MODELING, LAND USE AND DELINEATION

The selection of computer simulation modeling software for the Rio Grande de Loiza watershed was driven by an evaluation of technical functionality of the available models, available databases and user's specifications. Each model application has specific requirements for data input, both digital spatial data (soils, terrain, stream reaches, etc.) and tabular data of time-series parameters (rainfall, temperature, PET, etc.). Some models require low resolution, lumped data, while others assume that highly resolved data for the entire study area is available. The project team balanced these two elements in making its model selection. Finally, user specifications were a deciding factor in making the selection so that results and databases compiled in this modeling effort would be consistent with other efforts underway.

The watershed analysis performed required:

- One-hour time step in data input and model output for quality and quantity parameters
- Ability to vary source loads to the watershed or specific stream elements
- Ability to report on indicated catchments or sub-catchments
- Complex modeling of land use wash-off and pollutant loading
- Treatment of watershed base flow, interception and evapotranspiration
- In-stream modeling of pollutant transport

These requirements apply because the project area watershed is located in a tropical region, which has a specific precipitation and temperature regime. It is essential that the model be able to accurately model intense rainfalls in warm environments and to capture the groundwater behavior given the existing soil conditions. These factors are significant in generating accurate watershed stream flows and the significant variability that can occur on an hourly basis. These model requirements also entail the model functionality of employing the most detailed stream, terrain, land cover, soil and weather data available.

The EPA Loading Simulation Program C++ (LSPC) meets all of the requirements listed above and is currently employed in other TMDL projects that are ongoing. LSPC is a watershed modeling system that includes a subset of the Hydrologic Simulation Program Fortran (HSPF) functionality. HSPF is one of the most successful and widely used water quantity/quality models developed in the public domain. It includes elements for simulating hydrology, sediment and general water quality on land, as well as a simplified stream transport model. A key data management feature of this system is that it uses a Microsoft Access database to manage model data and weather text files for driving the simulation. The system also contains a module to assist in TMDL calculation and source allocations. For each model run, it automatically generates comprehensive text-file outputs by subwatershed for all land-layers, reaches and simulated modules, which can be expressed on hourly or daily intervals. The Visual C++ programming architecture provides a graphic user interface (GUI).

LSPC was designed to handle very large-scale watershed modeling applications. Using the Watershed Characterization System (WCS) extension, if the appropriate databases are available, speeds the model setup and execution. The system is tailored for source representation and TMDL calculation. LSPC includes a GIS interface, compatible with ArcView shape files that acts as the control center for launching watershed model scenarios.

The Rio Grande de Loiza watershed was delineated into 15 subwatersheds (see Figure IV-1) using the automatic delineation tool contained within Basins. The method uses the digital elevation model (DEM) of the watershed along the river network to delineate the entire watershed into a number of smaller watersheds. The subwatersheds were not independently checked against other data sources such as Digital Raster Graphics (DRGs), but based on visual comparisons to USGS topographical maps. The differences between the watershed boundary and the delineated subwatersheds, as based on digital elevation model (DEM) data, are small and comprise approximately 3% of the watershed drainage area.. To the extent that there are minor errors in the drainage area of the subwatershed, there could also be minor errors in the computed

Figure IV-1

subwatershed loads. The final delineation of the Rio Grande de Loiza watershed is presented in Figure IV-1 along with USGS and EQB monitoring stations, river network and the LSPC watersheds. For the land use characterization of the watershed, an ERDAS image was used. The image contained a total of 33 land use categories. For modeling purpose, these categories were grouped into 5 major land use categories. Table IV-1 shows all 33 ERDAS land use codes, their descriptions, their corresponding LSPC land use groups (LSPC LU Codes), and descriptions of each major group. Table IV-2 presents the subwatershed name, number and land use in acres. Table IV-3 summarizes the land use within drainage area for the entire Rio Grande de Loiza watershed. Figure IV-2 shows land use and watershed segments. The total drainage area is 126,514 acres (198 square miles) with land use percentages of approximately 35% forest, 5% cropland, 11% urban and 49% pasture.

Table IV-1

LAND USE CODES (LUs)
RIO GRANDE DE LOIZA

ERDAS LU Code	ERDAS Description	LSPC LU Code	LSPC Description
1	Lowland dry semi-deciduous forest	3	Forest
2	Lowland dry semi-deciduous woodland/shrub land	3	Forest
3	Lowland dry mixed evergreen drought-deciduous shrub land with succulents	3	Forest
4	Lowland dry and moist, mixed seasonal evergreen, sclerophyllous forest	3	Forest
5	Lowland moist evergreen hemisclerophylous shrub land	3	Forest
6	Lowland moist seasonal evergreen forest	3	Forest
7	Lowland moist seasonal evergreen forest/shrub	3	Forest
8	Lowland moist coconut palm forest	3	Forest
9	Lowland moist semi-deciduous forest	3	Forest
10	Lowland moist semi-deciduous forest/shrub	3	Forest
11	Lowland moist seasonal evergreen and semi-deciduous forest	3	Forest

ERDAS LU Code	ERDAS Description	LSPC LU Code	LSPC Description
12	Lowland moist seasonal evergreen and semi-deciduous forest/shrub	3	Forest
13	Submontane and lower montane wet evergreen sclerophyllous forest	3	Forest
14	Submontane and lower montane wet evergreen sclerophyllous forest/shrub	3	Forest
15	Submontane wet evergreen forest	3	Forest
16	Active sun/shade coffee, submontane and lower montane wet forest/shrub	3	Forest
17	Submontane and lower montane wet forest/shrub and active/abandoned shade coffee	3	Forest
18	Lower montane wet evergreen forest - tall and palm cloud forest	3	Forest
19	Lower montane wet evergreen forest - elfin and palm cloud forest	3	Forest
20	Lower montane wet evergreen forest - elfin and palm cloud forest	3	Forest
21	Tidally and semi-permanently flooded sclerophyllous forest	3	Forest
22	Seasonally flooded rainforest	3	Forest
23	Tidally flooded evergreen dwarf shrub land and forb vegetation	3	Forest
24	Other emergent wetlands (including seasonally flooded pasture)	7	Wetlands
25	Salt and mud flats	7	Wetlands
26	Pasture	4	Pasture
27	Agriculture/hay	2	Cropland
28	Agriculture	2	Cropland
29	Urban and barren	6 & 20	Urban
30	Sand and rock	6 & 20	Urban
31	Quarries	6 & 20	Urban
32	Sand and rock	6 & 20	Urban
33	Water	1	Water

Table IV-2

RIO GRANDE DE LOIZA
SUBWATERSHED INFORMATION

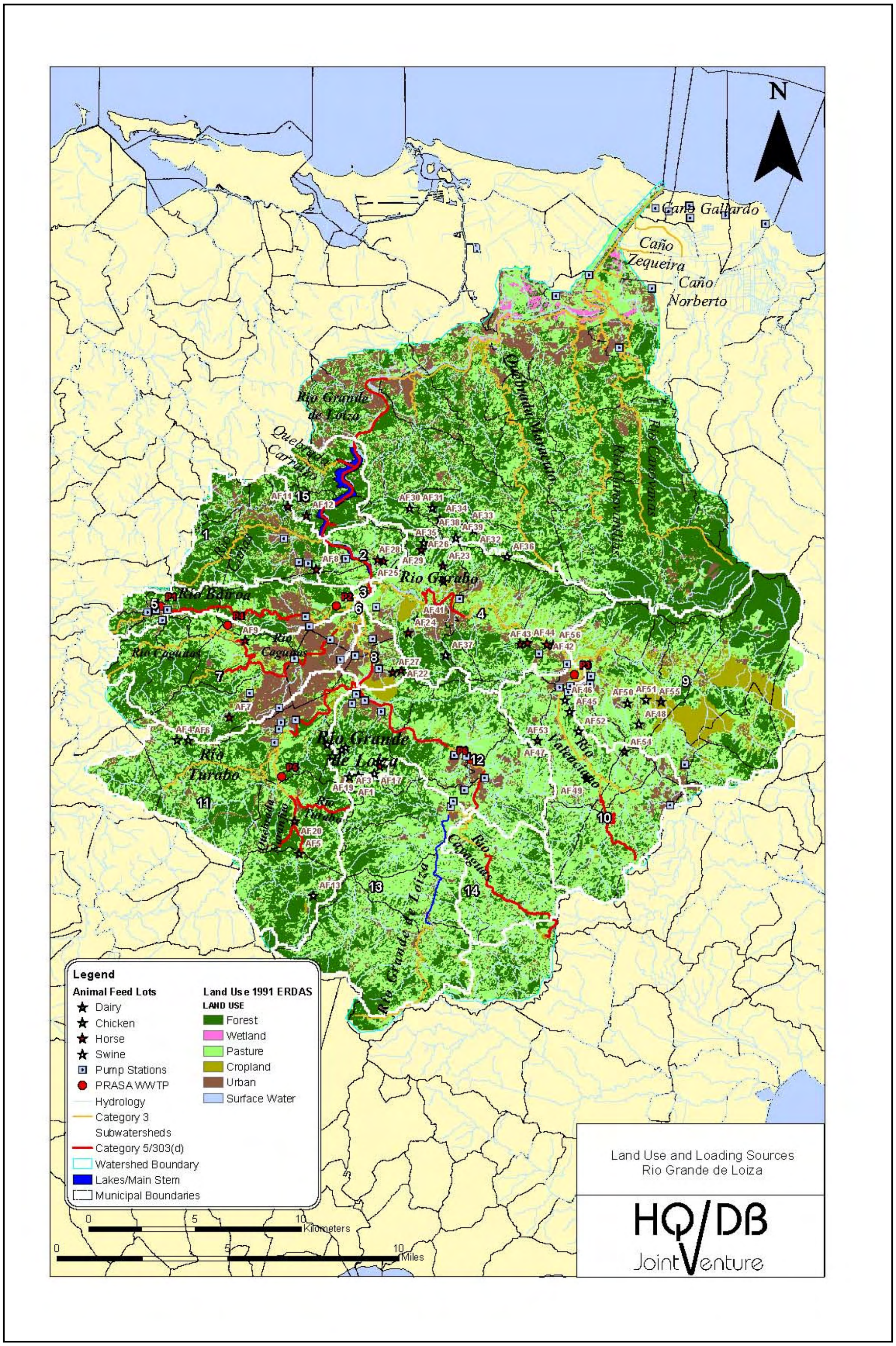
Subwatershed Number	Subwatershed Name	Cropland	Forest	Pasture (AFOs)	Urban	Wetlands	Total
1	Rio Canas	156.95	3852.94	1551.65	1070.54	0	6632.08
2	Lower Loiza (2)	39.48	765.72	1395	176.48	0	2376.68
3	Lower Loiza (3)	8.22	56.1	74.54	3.44	0	142.3
4	Rio Gurabo	916.77	4412.81	6456.1	1460.44	0	13246.12
5	Rio Bairoa	90.71	2557.2	1303.83	974.52	0	4926.26
6	Lower Loiza (6)	1.37	8.61	31.65	0	0	41.63
7	Rio Caguitas	291.24	4407.26	3850.61	2742.14	0	11291.25
8	Lower Loiza (8)	205.94	182.18	531.11	763	0	1682.23
9	Rio Gurabo (9)	3431.68	6293.92	8369.7	1281.36	12.81	19389.47
10	Rio Gurabo (10)	38.29	1789.23	8461.12	1315.08	0	11604.72
11	Rio Turabo	242.76	8550.46	7829.58	1976.28	0	18599.08
12	Upper Loiza (12)	280.93	3470.92	6714.96	1300.1	0	11766.91
13	Upper Loiza (13)	66.41	5414.66	9727.86	848.24	0	16057.17
14	Upper Loiza (14)	20.92	1119.69	4182.46	202.18	0	5525.25
15	Lago Loiza	0	1989.17	922.62	316.08	5.83	3,233.7
	Total	5,792.67	44,870.87	61,402.79	14,429.88	18.64	126,514.9

Table IV-3

LSPC LAND USES IN THE LOIZA WATERSHED

Land Use Type	Area (acres)	Percentage (%)
Cropland	5,793	4.6
Forest	44,871	35.5
Pasture	61,403	48.5
Urban	14,430	11.4
Wetlands	19	0.01
Total	126,515	

Figure IV-2


N
Caño Gallardo
Caño Zequeira
Caño Norberto
Rio Grande de Loiza
Quebrada Carraizo
Rio Gurabo
Rio Bairoa
Rio Caguitas
Rio Cagüitas
Rio Turabo
Rio Grande de Loiza
Rio Valenciano
Rio Cayaguas
Legend
Animal Feed Lots
Dairy
Chicken
Horse
Swine
Pump Stations
PRASA WWTP
Hydrology
Category 3
Subwatersheds
Category 5/303(d)
Watershed Boundary
Lakes/Main Stem
Municipal Boundaries
Land Use 1991 ERDAS
LAND USE
Forest
Wetland
Pasture
Cropland
Urban
Surface Water
0 5 10 Kilometers
0 5 10 Miles
Land Use and Loading Sources
Rio Grande de Loiza
HQ/DB
Joint Venture

2.0 WATER QUALITY PROBLEMS

In Section 1.0, Table I-1 provides the Impaired Waters from the 2004 303(d) List. The listings provide the Parameters of Interest (POI) for which TMDLs should be developed. for each assessment unit. The table presents the listed water body, assessment unit, water body size and POIs. For the Rio Grande de Loiza Basin, fecal coliform is listed for every water body except for Lake Loiza, which is listed for low dissolved oxygen. The remaining POIs are arsenic, cyanide, copper, lead, ammonia and low DO. Figure IV-3 presents the impaired waters (Category 5) in red, along with basin and municipal boundaries, monitoring stations and the hydrology in each basin.

A review of the Puerto Rico Aqueduct and Sewer Authority (PRASA) wastewater and water treatment plants reported effluent data was undertaken and supplemented with field inspections of each. The purpose was to identify parameters which could be candidates as potential POIs in addition to those arising from the evaluation of the impaired water bodies list. The permit limits and 2004 discharge values were analyzed for discharge parameters exhibiting a consistent pattern of exceedance permits limits. Where this was found, they were classified into: (1) parameters where Method Detection Levels greater than permitted discharge values are being used and may be contributing to the violation (arsenic, lead, cadmium and sulfide) and (2) parameters which seem to be consistently violating permit discharge limits on a widespread basis (phosphorus, copper, mercury, coliform (total and fecal) and ammonia).

The Table IV-4 provides a comprehensive listing of the POIs that were studied and the reason for including the POI.

Table IV-4

POLLUTANTS OF INTEREST

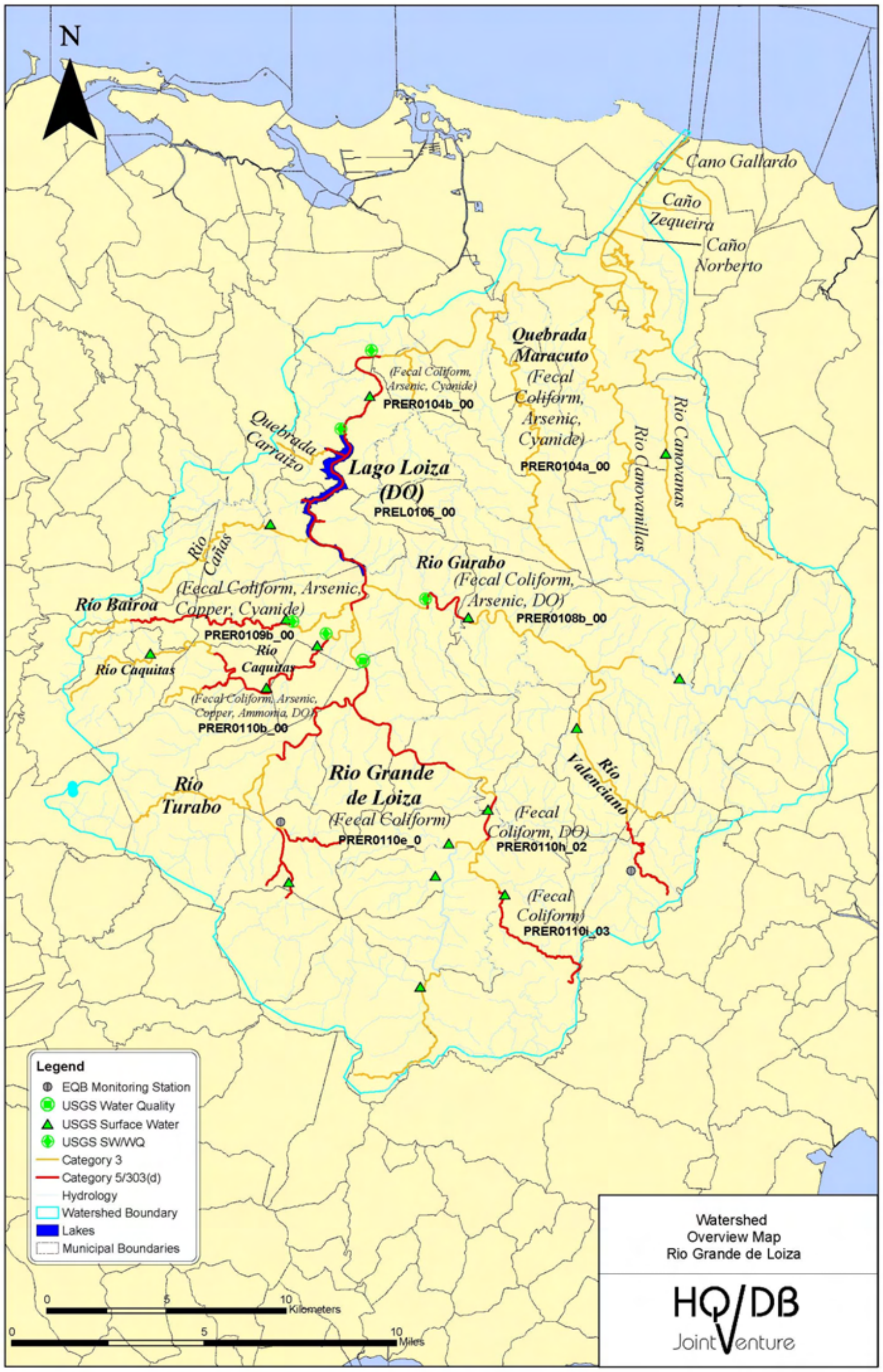
POI	Class SD WQS	Reasons for Inclusion
Ammonia	1 mg/l at specified locations**	303(d) List NPDES Compliance
Arsenic	0.18 µg/l	303(d) List Method Detection Level
Copper	$e^{(0.8545 \times \ln(\text{hardness}) - 1.702)}$ – µg/l	303(d) List NPDES Compliance
Cyanide	5.2 µg/l	303(d) List
DO	Not less than 5 mg/l except when natural conditions cause DO to be depressed below this value	303(d) List
Fecal Coliform	Geometric mean of 200 col/100 mL (at least 5 samples) with no more than 20% of samples exceeding 400 col/100 mL	303(d) List NPDES Compliance
Total Coliform	The coliform geometric mean of a series of representative samples (at least five samples) of the waters taken sequentially shall not exceed 10000 colonies/100 ml of total coliform	NPDES Compliance
Lead	$e^{(1.273 \times \ln(\text{hardness}) - 4.705)}$ – µg/l	303(d) List Method Detection Level
Selenium	5.0 µg/l	303(d) List
Surfactants	100 µg/l (as MBAS – methylene blue active substances identified by Standard Methods as anionic surfactants)	303(d) List (LaPlata Basin only)
Cadmium	$e^{(0.7852 \ln(\text{hardness}) - 2.715)}$ – µg/l	NPDES Compliance Method Detection Level
Sulfide	2.0 µg/l	NPDES Compliance Method Detection Level
Phosphorous	1.0 mg/l	NPDES Compliance
Mercury	0.050 µg/l/0.012 µg/l**	NPDES Compliance

POI	Class SD WQS	Reasons for Inclusion
Clean Sediment	---	USEPA

* Rio Bairoa - Latitude 18-15-28 and Longitude 66-02-13
Rio Caguitas - Latitude 18-15-11 and Longitude 66-01-26

** National Toxic Rule Criteria

Figure IV-3


N
Cano Gallardo
Caño Zequeira
Caño Norberto
Quebrada Maracuto (Fecal Coliform, Arsenic, Cyanide)
PRER0104a_00
Rio Canovanas
Rio Canovanillas
(Fecal Coliform, Arsenic, Cyanide)
PRER0104b_00
Quebrada Carraizo
Lago Loiza (DO)
PREL0105_00
Rio Cañas
Rio Gurabo (Fecal Coliform, Arsenic, DO)
PRER0108b_00
Rio Bairoa
(Fecal Coliform, Arsenic, Copper, Cyanide)
PRER0109b_00
Rio Caquitas
Rio Caquitas
(Fecal Coliform, Arsenic, Copper, Ammonia, DO)
PRER0110b_00
Rio Turabo
Rio Grande de Loiza (Fecal Coliform)
PRER0110e_0
(Fecal Coliform, DO)
PRER0110h_02
Rio Valenciano
(Fecal Coliform)
PRER0110i_03
Legend
EQB Monitoring Station
USGS Water Quality
USGS Surface Water
USGS SW/WQ
Category 3
Category 5/303(d)
Hydrology
Watershed Boundary
Lakes
Municipal Boundaries
0 5 10 Kilometers
0 5 10 Miles
Watershed Overview Map Rio Grande de Loiza
HQ/DB Joint Venture

A comprehensive review of USGS water quality data, Puerto Rico Environmental Quality Board (EQB) water quality data sampled at the same USGS water quality stations and EQB's non-point source network water quality data for the POIs identified was performed. Appendix A includes a series of plots which are useful in interpreting the data. USGS water quality data and river flows are presented as chronological plots for the most recent 10-year period of available data (1994 - 2003). Additionally, USGS and EQB's water quality data at the USGS stations are presented in chronological plot to show temporal and annual trends over the available 5-year time period (2001-2005). Data are also presented as probability distributions to show compliance with water quality standards and differences in the two data sets. EQB water quality data at EQB stations contains data collected over the time period 1997 to 2004, but does not include any metals, cyanide or surfactant data. This water quality data is also presented in the same format. Appendix A includes all plots. From the water quality analysis, Table IV-5 presents the POIs and the Assessment Units where TMDLs are to be developed and recommendations for Assessment Units where TMDLs are not being developed at this time.

Table IV-5

TMDL SUMMARY
FOR ALL 303(d) AND OTHER POLLUTANTS
RIO GRANDE DE LOIZA WATERSHED

POI	Reasons for Inclusion	303(d) Listed Segments	TMDL to be Developed	Reason for No TMDL
Ammonia	303(d) List NPDES Compliance	Rio Caguitas (110b_00) Rio Grande de Loiza (110h_02) Rio Bairoa (109b_00) - (added)	Yes No Yes	Analysis of ambient water quality data shows ammonia violations only in the Rio Bairoa and Rio Caguitas. The Rio Grande de Loiza (110h_02) does not have a water quality standard for ammonia. The San Lorenzo WWTP (the facility not complying occasionally with its permit limit for ammonia) discharges downstream of this segment (110h_02). Furthermore, EQB monitoring station L-2 which shows D.O. violations is located on the Quebrada Sin Nombre, not the Rio Grande de Loiza. A D.O. based TMDL will be performed on the Quebrada Sin Nombre.

POI	Reasons for Inclusion	303(d) Listed Segments	TMDL to be Developed	Reason for No TMDL
Arsenic	303(d) List	Rio Grande de Loiza (104b_00) Rio Gurabo (108b_00) Rio Bairoa (109b_00) Rio Caguitas (110b_00)	No No No No	Ambient water quality sampling data conducted by EPA in October 2005 showed arsenic levels ranging from approximately 0.6 ug/l to 1.5 ug/l. This data would tend to confirm the assumption based upon USGS and EQB ambient water quality data (detection levels exceed the standard) which show the arsenic water quality standard violated in the listed segments. The EPA sampling found levels are, however, being detected upstream of any wastewater treatment plants or other identifiable point or non-point sources of pollution and are actually higher (in all but one case) than the levels being discharged by the PRASA wastewater treatment plants. Arsenic appears to be present in water as the result of its presence in the soils in Puerto Rico and is in that soil either as a naturally occurring substance or the product of past agricultural practices. Development of arsenic TMDL at this time would not produce meaningful end products as unknown nonpoint sources appear to be causing the instream violations. We recommend a track down and monitoring program be a part of a Phase 2 TMDL program.
Copper	303(d) List NPDES Compliance	Rio Bairoa (109b_00) Rio Caguitas (110b_00) Rio Gurabo (108b_00)	Yes Yes No	For the Rio Gurabo segment, review of EQB ambient water quality data shows values at detection levels and below the water quality standard. This segment should be de-listed.
Cyanide	303(d) List	Rio Grande de Loiza (104b_00) Rio Bairoa (109b_00) Rio Caguitas (110b_00)	No No No	Review of EQB ambient water quality data shows values at detection levels above the WQS. WWTP compliance data shows sporadic exceedance of WQS by the effluent. We recommend monitoring to determine whether or not the standard is being violated as part of a Phase 2 TMDL.

POI	Reasons for Inclusion	303(d) Listed Segments	TMDL to be Developed	Reason for No TMDL
DO	303(d) List	Rio Gurabo (108b_00)	Yes	For Lake Loiza a phosphorous TMDL will be developed to produce an acceptable trophic level which will eliminate violations of narrative WQSs and approach an acceptable DO levels. EQBs L-2 monitoring station is located on the Quebrada Sin Nombre. Review of ambient water quality data shows dissolved oxygen violations on the Quebrada Sin Nombre, not the Rio Grande de Loiza (110h_02).
		Rio Caguitas (110b_00)	Yes	
		Lake Loiza (105_00)	No	
		Rio Grande de Loiza (110h_02)	No	
		Quebrada Sin Nombre (added)	Yes	
		Rio Bairoa (109b_00) (added)	Yes	
Fecal Coliform	303(d) List NPDES Compliance	Rio Gurabo (108b_00)	Yes	The Rio Grande de Loiza Assessment unit (104b_00) is downstream of Lake Loiza and is not part of this study's scope.
		Rio Gurabo (Valenciano) (0108h_02)	Yes	
		Rio Bairoa (109b_00)	Yes	
		Rio Caguitas (110b_00)	Yes	
		Rio Grande de Loiza (110e_02)	Yes	
		Rio Grande de Loiza (Turabo) (110f_02)	Yes	
		Rio Grande de Loiza (110h_02)	Yes	
		Rio Grande de Loiza (110i_03)	Yes	
		Rio Grande de Loiza (104b_00)	No	
		The Rio Grande de Loiza watershed was divided into 15 subwatersheds. The watershed model shows fecal coliform exceeding water quality standards throughout the watershed. Seven (7) subwatersheds have been added including Lago Loiza (PREL0105_00). 15 Category 3 AUs are located in the 15 subwaterheds.	Yes	

POI	Reasons for Inclusion	303(d) Listed Segments	TMDL to be Developed	Reason for No TMDL
Total Coliform	NPDES Compliance	N/A	No	Total Coliform will be addressed through the implementation controls for the fecal coliform TMDL.
Lead	303(d) List Method Detection Level	Rio Caguitas (110b_00)	No	Review of EQB ambient water quality data shows values at detection levels. EPAs sampling using clean techniques resulted in levels at lower detection levels and below water quality standard. Additionally, there are no point sources on this segment for which WLA could be developed. We recommend sampling and de-listing as part of a Phase 2 TMDL.
Cadmium	NPDES Compliance	N/A	No	Review of EQB ambient water quality data shows values at detection levels and below the water quality standard. NPDES compliance issues are method detection level related. No further action is recommended.
Sulfide	NPDES Compliance Method Detection Level	N/A	No	Review of EQB ambient water quality shows values at detection levels which are greater than the WQS. All WWTPs show discharges which are at or below the WQS. No further action is recommended.
Phosphorous	NPDES Compliance	N/A	Yes	Phosphorus limit controls will be placed on all sources upstream of lakes as part of a TMDL aimed at producing acceptable lake trophic level, which will eliminate violations of narrative WQSs and approach acceptable DO levels.
Mercury	NPDES Compliance	N/A	No	Review of EQB ambient water quality data shows values mostly at detection levels and always below water quality standards.
Clean Sediment	USEPA	N/A	No	To develop a TMDL for sediment is beyond the scope of this study. However, the need for and options for control of sediment to the lakes will be evaluated. We recommend a sediment TMDL be developed as part of Phase 2 TMDL program

3.0 POLLUTANT SOURCES

Figure IV-2 shows the land use and the model segments. All National Pollutant Discharge Elimination System (NPDES) point source discharges and NPDES non-filers are shown on Figure IV-4. PRASA pump stations and EQB permitted animal feeding operations are shown in Figures IV-5 and IV-6, respectively. Appendix B provides the locational data on the points sources and animal feeding operations.

The point sources discharge many of the parameters of interest. These point sources are water treatment plant discharges, wastewater treatment plant discharges, pump station failures, and non-municipal wastewater discharges (industrial facilities, schools, etc.). Pump station failures and sanitary sewer overflows are estimated at 1% of the wastewater treatment plant flow.

Non-point sources (diffuse) also contribute the parameters of interest to the water bodies. These sources include runoff from animal feeding operations, urban areas, croplands, forested lands, pastures and failing septic tanks.

- Animal feeding operations located in each LSPC watershed segment were broken down by animal type and count. Table IV-6 provides the animal counts in the watershed segments. Chicken and swine operations consisted of confined animal areas with associated waste management systems. Discharges from the waste management systems are assigned to pasture land while applications of manure for fertilizer are assigned to cropland. The horse and dairy cow operations are assumed to allow animals to roam in pasture areas.

- The 2000 Census and sewered populations in each municipality were utilized to develop sewered and unsewered population estimates for each LSPC segment. Table IV-7 provides the LSPC segment, total population, sewered population and unsewered population. The populations sewered were based upon discussions and information obtained in visits to PRASA Regional offices.

- Forested lands loads are assigned for the appropriate parameters of interest.

Figure IV-4

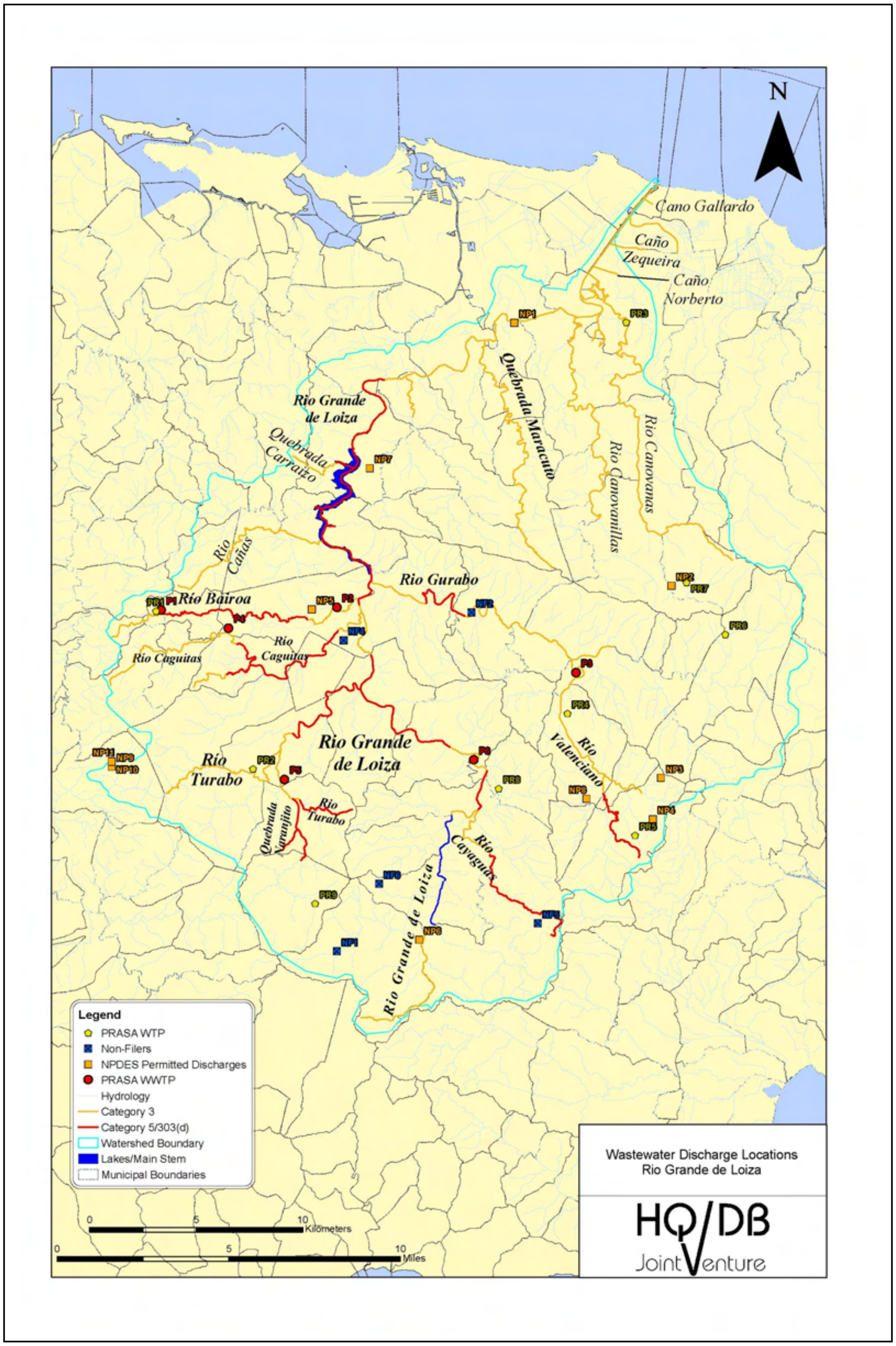

N
Cano Gallardo
Caño Zequeira
Caño Norberto
Quebrada Maracuto
Rio Canovanas
Rio Canovanillas
Rio Grande de Loiza
Quebrada Carraizo
Rio Cañas
Rio Gurabo
Rio Bairoa
Rio Caguitas
Rio Caguitas
Rio Grande de Loiza
Rio Turabo
Rio Turabo
Quebrada Naranjito
Rio Valenciano
Rio Cayaguas
Rio Grande de Loiza
Legend
PRASA WTP
Non-Filers
NPDES Permitted Discharges
PRASA WWTP
Hydrology
Category 3
Category 5/303(d)
Watershed Boundary
Lakes/Main Stem
Municipal Boundaries
0 5 10 Kilometers
0 5 10 Miles
Wastewater Discharge Locations
Rio Grande de Loiza
HQ/DB
Joint Venture

Figure IV-5

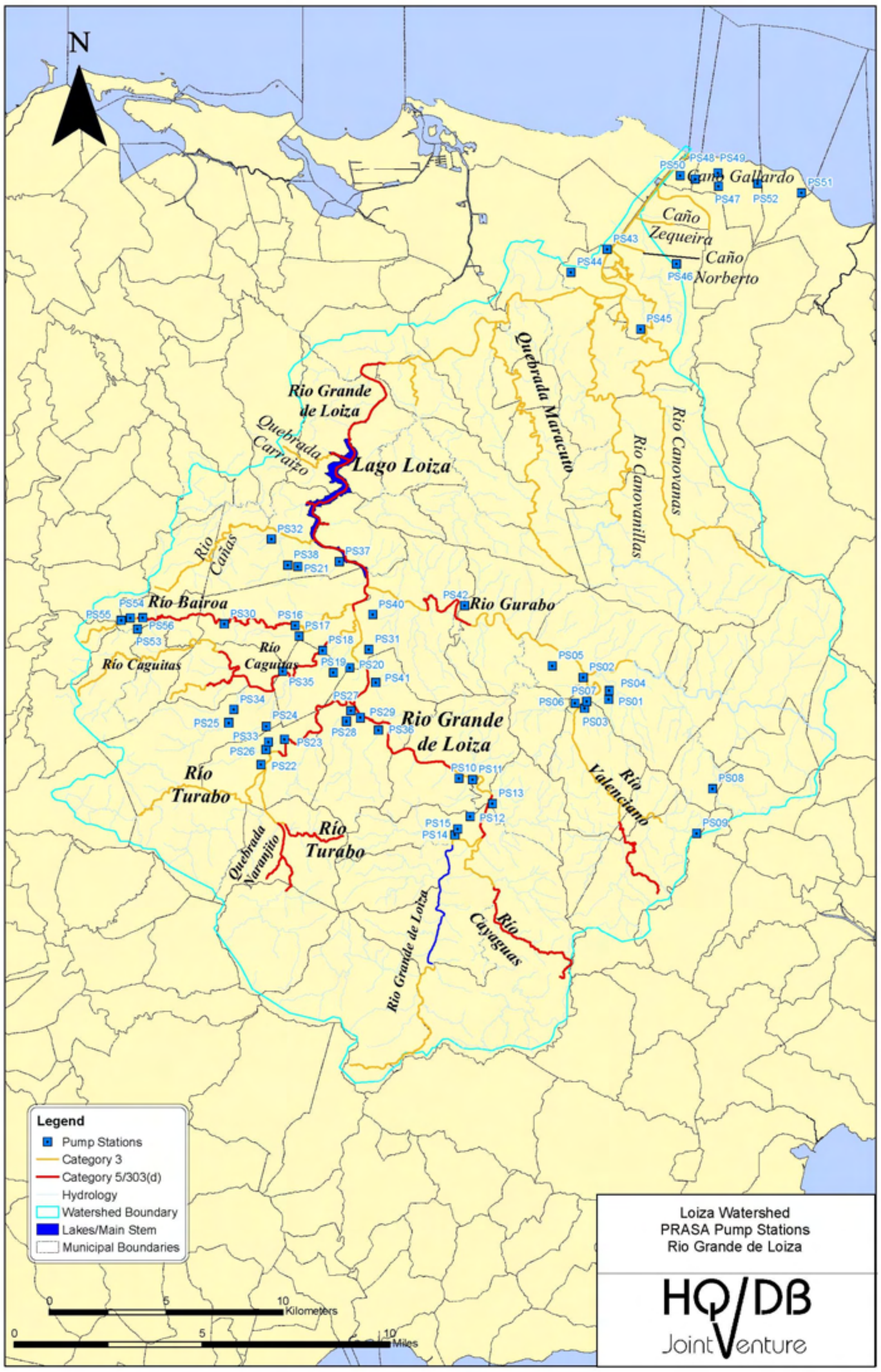
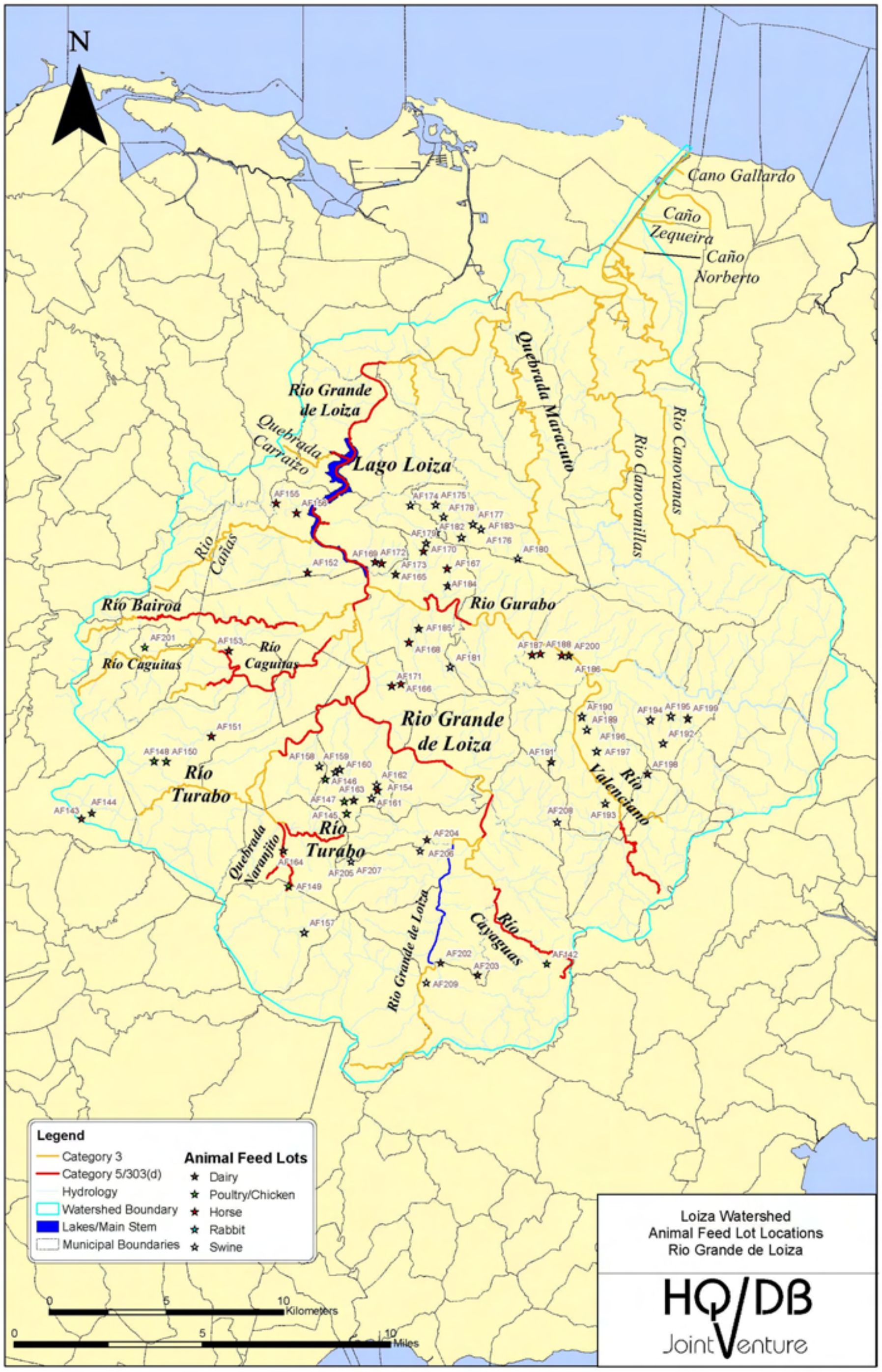

N
Caño Gallardo
Caño Zequeira
Caño Norberto
Quebrada Maracuto
Río Canóvanas
Río Canovanillas
Río Grande de Loiza
Quebrada Carraizo
Lago Loiza
Río Cañas
Río Bairoa
Río Gurabo
Río Caguitas
Río Caguitas
Río Grande de Loiza
Río Valenciano
Río Turabo
Quebrada Naranjito
Río Turabo
Río Grande de Loiza
Río Cayaguas
PS01
PS02
PS03
PS04
PS05
PS06
PS07
PS08
PS09
PS10
PS11
PS12
PS13
PS14
PS15
PS16
PS17
PS18
PS19
PS20
PS21
PS22
PS23
PS24
PS25
PS26
PS27
PS28
PS29
PS30
PS31
PS32
PS33
PS34
PS35
PS36
PS37
PS38
PS40
PS41
PS42
PS43
PS44
PS45
PS46
PS47
PS48
PS49
PS50
PS51
PS52
PS53
PS54
PS55
PS56
Legend
Pump Stations
Category 3
Category 5/303(d)
Hydrology
Watershed Boundary
Lakes/Main Stem
Municipal Boundaries
0 5 10 Kilometers
0 5 10 Miles
Loiza Watershed
PRASA Pump Stations
Rio Grande de Loiza
HQ/DB
Joint Venture

Figure IV-6



N
Cano Gallardo
Caño Zequeira
Caño Norberto
Quebrada Maracuto
Rio Canovanas
Rio Canovanillas
Rio Grande de Loiza
Quebrada Carraizo
Lago Loiza
Rio Cañas
Rio Bairoa
Rio Caguitas
Rio Caguitas
Rio Gurabo
Rio Grande de Loiza
Río Turabo
Río Turabo
Quebrada Naranjito
Rio Valenciano
Rio Cayaguas
Rio Grande de Loiza
Legend
Category 3
Category 5/303(d)
Hydrology
Watershed Boundary
Lakes/Main Stem
Municipal Boundaries
Animal Feed Lots
Dairy
Poultry/Chicken
Horse
Rabbit
Swine
0 5 10 Kilometers
0 5 10 Miles
Loiza Watershed
Animal Feed Lot Locations
Rio Grande de Loiza
HQ/DB Joint Venture

Table IV-6

LOIZA ANIMAL COUNTS

LSPC Segment	Horse	Dairy Cow	Chicken	Swine	Total
1	146	–	–	–	146
2	94	–	–	–	94
4	390	1,398	–	152	1,940
7	85	–	–	–	85
8	66	–	–	–	66
9	–	1,276	–	282	1,558
10	–	990	–	893	1,883
11	–	90	144,000	334	144,424
12	50	491	55,000	544	56,085
13		Unknown		Unknown	
14			30,000		
Total	831	4,245	229,000	2,205	236,281

Notes:

Animal operations were not located in LSPC segments 3, 5, 6, and 15. In segment 13 dairy and swine operations exist but the number of animals is unknown.

Table IV-7

LOIZA SEWERED/UNSEWERED POPULATION

LSPC Segment	Total Population	Sewered Population	Unsewered Population	% Unsewered
1	14,050	7,206	6,844	49
2	2,930	1,373	1,557	53
3	500	0	500	100

LSPC Segment	Total Population	Sewered Population	Unsewered Population	% Unsewered
4	32,872	10,740	22,132	67
5	13,793	11,591	2,202	16
6	300	0	300	100
7	67,662	44,516	23,146	34
8	4,908	0	4,908	100
9	29,026	13,894	15,132	52
10	23,121	6,215	16,906	73
11	38,550	20,666	17,884	46
12	38,009	11,182	26,827	71
13	16,904	0	16,904	100
14	5,785	0	5,785	100
15	8,119	0	8,119	100
Total	296,529	127,383	169,146	57

To develop pollutant loads for the pollutant sources the following was utilized:

- Septic system failures are estimated at 50 percent of the unsewered population in the watershed with 95 percent of the failures resulting in overland runoff on pervious urban area. Visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50%, and a flow of 50 gallons per capita per day (50 GPCD) to estimate the loadings to the applicable assessment unit from this source as specified in each TMDL support document. (The *USEPA Onsite Wastewater Treatment Systems Manual* [EPA-625-R-00-008; 02/01/2222] provides an estimate of average daily wastewater flows in residential systems of between 50 and 70 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 utilized to provide loading information during the Phase 1 process. The Phase 2 program is expected to further refine and confirm the estimate of flow and failure rate as well as the estimate of pollutant strength and result in a more refined estimate of pollutant loading.) The 95% of failures resulting in overland runoff was based on model calibration. Septic tank failures in impervious urban areas are assigned loads as described below.

- A fecal coliform concentration of 1e6 #/100mL were assigned to the flow based on typical untreated sewage values (Metcalf and Eddy, 1991) and model calibration. The loadings were split into both direct and indirect sources. As stated in the preceding, 5% of the failing septic tanks were assumed to discharge directly to a water body while the remaining 95% were assigned to overland runoff processes on pervious urban areas (LSPC buildup/wash-off) assuming that the failing septic system overflow load remains on the land until runoff events wash-off the built-up failing septic tank load. The resulting septic tank fecal coliform buildup rate was 2.60e10 (ACQOP) #/acre/day with a limiting buildup of 4.68e10 #/acre (SQOLIM). This split was based on the model calibration since information was not available to determine the split. Initial model runs with larger percentages going directly to the stream resulted in a point source dominated system (higher concentrations at low flow than high flow) than the data suggested (typically higher concentrations at high flow). In addition, impervious urban fecal coliform loads were assigned based on a buildup rate of 1.13e7 (ACQOP) #/acre/day and a limiting buildup of 2.03e7 #/acre (SQOLIM) as specified in the USEPA Bacterial Indicator Tool for a mixed urban land use.

- To develop loads from animal feeding operations, animal fecal coliform loading rates were used based on information contained in the USEPA Bacterial Indicator Tool (USEPA, 2000). The fecal coliform loading rates used to calculate loads (#/day) were 4.19e8 #/animal/day for horses, 5.36e10 #/animal/day for dairy cows, 1.88e8

#/animal/day for chickens, and 1.02e10 #/animal/day for swine. In addition, it was assumed that 35% of the calculated load is actually available for wash-off from the land. The 35% that is available for wash-off was based on the La Plata Fecal Coliform TMDL (Horsley and Witten, 2003). For chicken and swine, it was assumed that there was a 10% failure rate of the waste management systems with the load assigned to pasture land using the buildup/wash-off component of LSPC. Of the remaining chicken/swine fecal coliform load, 25% was assumed available for buildup/wash-off on cropland due to manure application for fertilizer. The 10% waste management system failure rate with 25% available for buildup/wash-off was estimated and based on model calibration. For the horses and cows, the fecal coliform load was assigned to pasture using the buildup/wash-off component of LSPC. The final sediment associated parameters, buildup rates (ACQOP) and limiting buildup (SQOLIM) for the calibration are presented in Table IV-8 for each land use. For fecal coliform, these parameters were determined from the USEPA Bacterial Indicator Tool reference information and watershed specific information on septic systems and animal counts.

- For forested land, the fecal coliform load was associated with wildlife in the forest areas (50% of production available for wash-off) using a fecal coliform loading rate of 8.43e9 #/animal/day, based on the USEPA Bacterial Indicator Tool, and a wildlife density of 10 animals/mi^2 (estimated) again using the buildup/wash-off component of LSPC.

Table IV-8

LSPC CALIBRATED SEDIMENT RELATED AND BUILDUP/WASH-OFF PARAMETERS

Land Use	FC ACQOP (#/acre/day)	FC SQOLIM (#/acre)
Pasture	1.33e9	2.40e9
Cropland	8.14e8	1.47e9
Forest	6.59e7	1.19e8
Urban Pervious	2.60e10	4.68e10
Urban Impervious	1.13e7	2.03e7

4.0 WATER QUALITY MODEL CALIBRATION

For the Loiza watershed model calibration analyses were performed for river flow, and fecal coliform bacteria. In the Loiza watershed, the most comprehensive data set for bacteria is data collected by the USGS at four stations: Rio Gurabo, Rio Bairoa, Rio Caguitas, and Rio Grande de Loiza near Caguas. The hydrologic model was calibrated against five years (2000-2004) of daily flows at four USGS stations. Bacterial models were calibrated against data collected over four years (2000-2003) with 3 to 4 measurements per year. Hydrology (flow) and fecal coliform were calibrated with data from the following USGS stations: Rio Gurabo (#50057000/50057025), Rio Bairoa (#50055390/50055380/50055400), Rio Caguitas (#50055225/50055250), and Rio Grande de Loiza (#50051800/50055000). These stations were selected for model calibration due to completeness of the data record with emphasis on stations located at downstream locations in the subwatersheds. Available bacterial data prior to 2000 were not used because it appears higher loadings in some basins prior to 2000 no longer occur and, therefore, data prior to 2000 do not represent existing conditions.

The annual computed runoff in a watershed is primarily a function of the difference between rainfall and evapotranspiration rate with some potential change in groundwater storage. Short term runoff patterns are also dependent upon storage in the upper and lower soil zones. In the Loiza watershed rainfall from three rain gages were used to assign rainfall to each subwatershed. Daily rainfall data for the five year model calibration period were shown in Figure IV-7 for the rainfall stations at Gurabo, Juncos, and San Lorenzo. The annual precipitation during this period ranged from 49.4 inches to 118.9 inches, with greater rainfall occurring in the higher elevation at San Lorenzo. At Gurabo, daily evaporation rates were also measured during the five year period. A summary of the measured monthly evaporation rates is shown in Figure IV-8. These data were used to provide estimates of the potential evapotranspiration rates used in the LSPC model. Other hydrologic model coefficients that describe soil moisture storage, groundwater recession, and other factors affecting computed runoff are contained in Appendix C.

The hydrology model results are compared to measured runoff on an annual, monthly and daily basis. Figure IV-9 shows the measured and computed total volume of runoff for each year at three USGS stations. The fourth station (Rio Bairoa) was not used due to incomplete flow records. Because there were partial flow records for the Rio Bairoa stations, annual volumes are not compared. On an average, the computed annual runoff volumes are within +/-15% of the measured runoff on an annual basis and within +/-5% overall. The greatest uncertainty in the calculated annual runoff is the rainfall for each of the fifteen subwatersheds modeled because there are only three rainfall gages for approximately 200 square miles of drainage area. Figure IV-10 presents a plot of the computed monthly runoff versus the measured runoff for the five year record at the four USGS gages. The calculated monthly volumes are in general agreement with measured volumes with some scatter, but there is some bias in the computed monthly volumes being lover than the measured volumes during low flow months. Finally, model and data are compared in Figure IV-11 for the four USGS stations. The calculated daily flows are directly related to rainfall and discrepancies between computed and measured daily flows are likely due to uncertainty in rainfall for a specific subwatershed. The computed daily flows are lower than measured flows when river flows are low. This bias may be due to the model not properly representing base flow from groundwater.

The results of the bacterial calibration are shown in Figures IV-12. The bacterial calibration represents dilution of bacterial loads from these same sources, but also includes a first order die-off rate of 2.0/day in the river. The 2.0/day fecal coliform die-off rate used is a nominal rate and is within the typical range of reported rates, 0.1-2.0/day (USEPA, 1991). The model routes water in the stream reaches from upstream to downstream. For example, LSPC segment 13 and 14 flow into segment 12 which then flows downstream into segments 8, 6, 3, 2 and 15 (Lago Loiza). Upstream and external loads enter each model segment with a mass balance calculated around the segment, along with the segment travel time and die-off rate to calculate instream concentrations. The model coefficients for the phosphorous and bacteria calibration are tabulated in Appendix C.

The adequacy of the model calibration for bacteria was based on a visual comparison of computed versus measured data in Figures IV-12. Because there is considerable uncertainty in some of the potential significant bacteria loads, such as septic systems and pasture land, difference between model results and data may be due to uncertainty in loads in addition to model coefficients. After more information on bacterial loads is collected during Phase II studies, it will be appropriate to present statistical comparisons between model and data on the revised model calibration analysis.

Overall, the model captures the spatial and temporal dynamics in flow, total phosphorus and fecal coliform, including the cause and effect relationships between sources (loads) and instream concentrations. Recognizing that this is a Phase I TMDL and additional data collection and ground truthing is planned for Phase 2, the Loiza watershed model is recommended for use in developing the TMDLs.

Figure IV-7

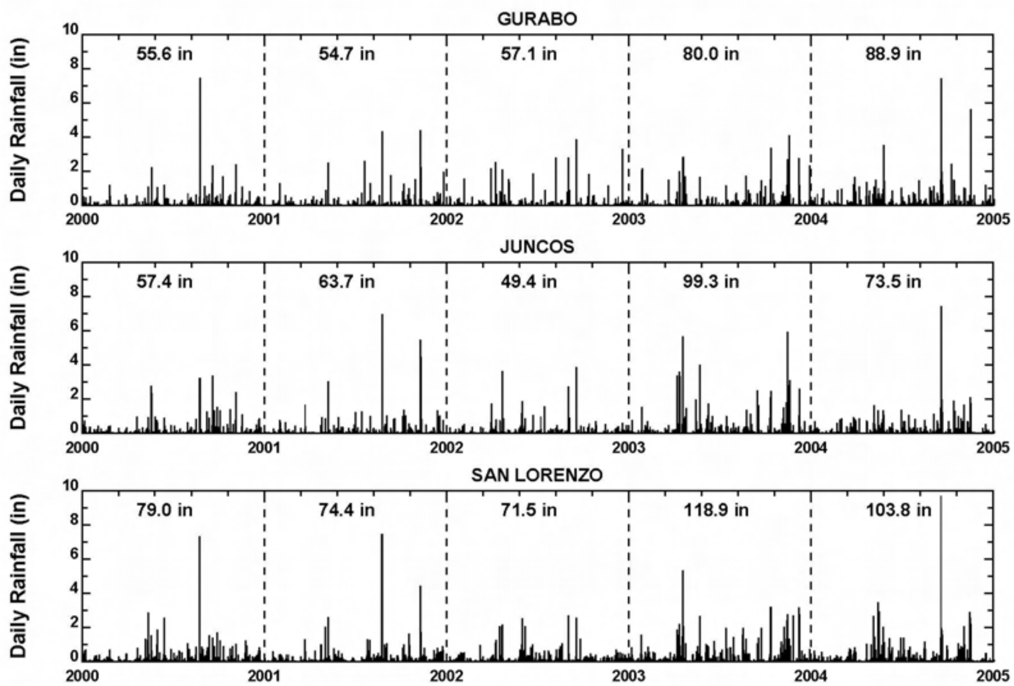


Figure IV-7: Meteorological Stations - Rio Grande de Loiza Watershed

Figure IV-8

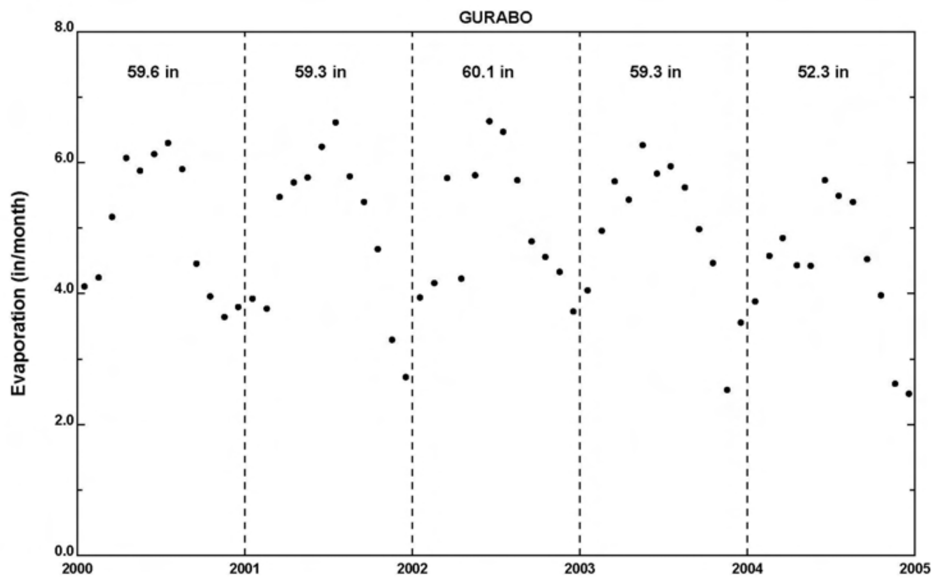


Figure IV-8: Monthly evapotranspiration - Gurabo Meteorological Station at Rio Grande de Loiza Watershed

Figure IV-9

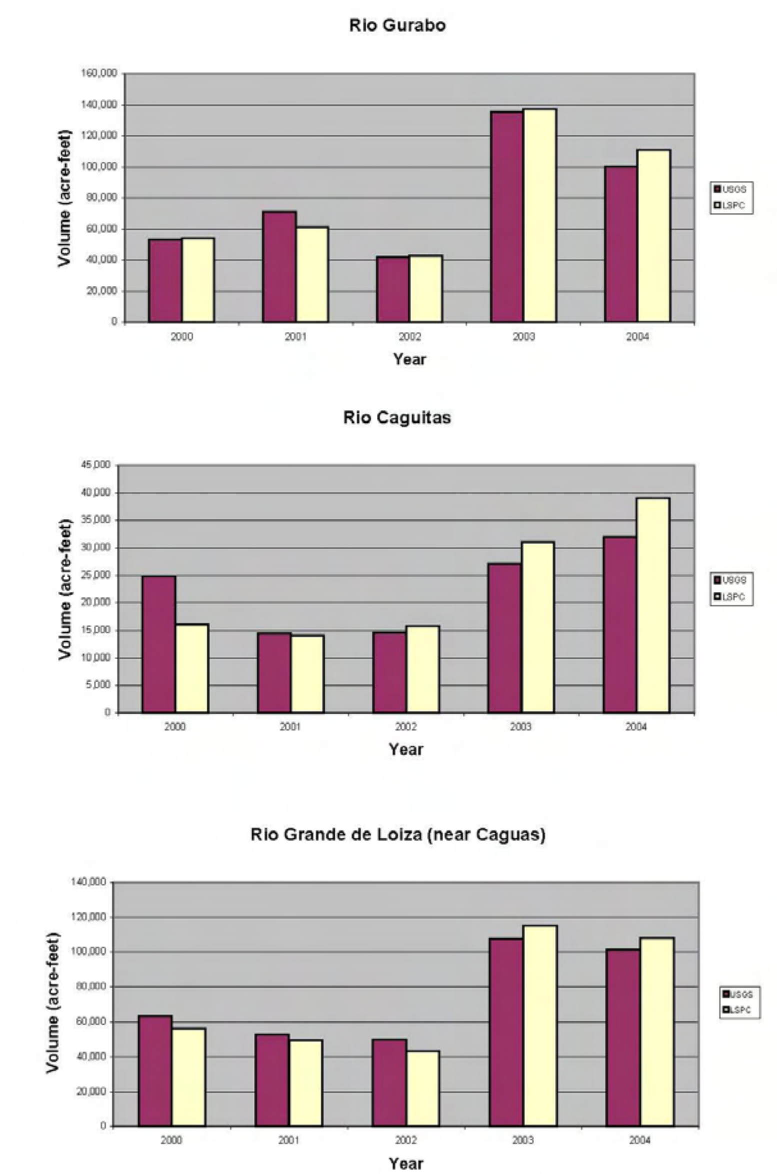


Figure IV-9: Flow Calibration - Annual Volumes

Figure IV-10

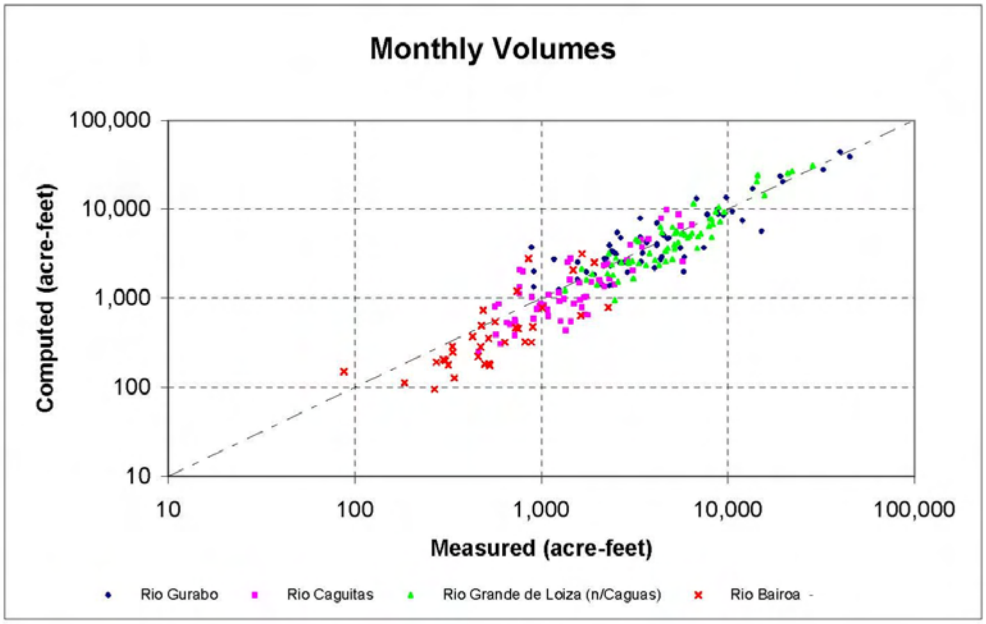


Figure IV-10: Flow Calibration - Monthly volumes

Figure IV-11

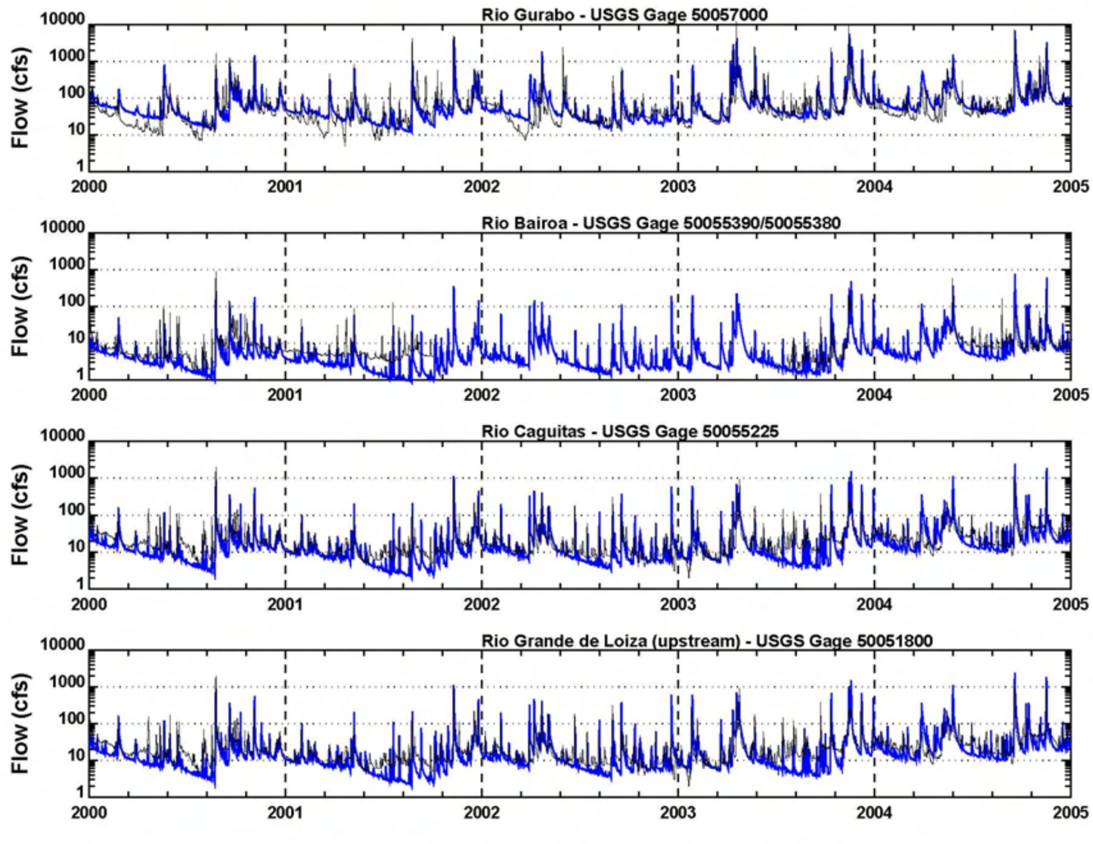


Figure IV-11: Flow calibration - Rio Grande de Loiza watershed

Figure IV-12

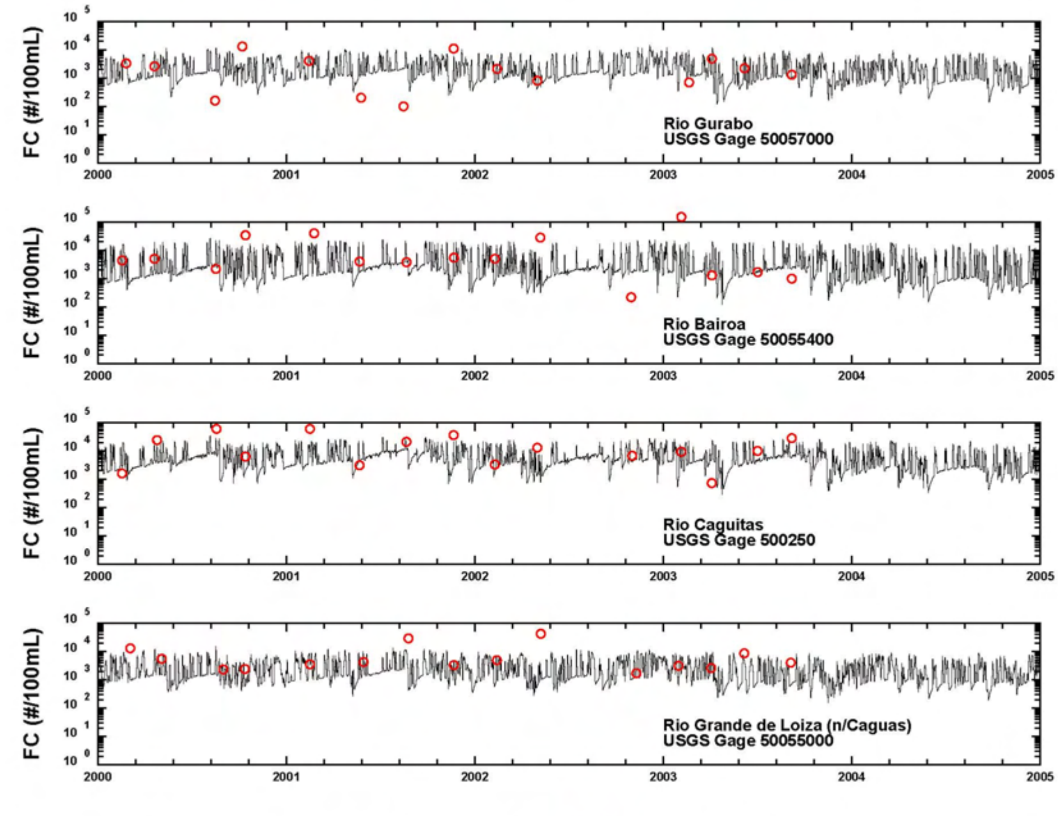


Figure IV-13: Fecal coliform calibration - Rio Grande de Loiza watershed

V. RIO GRANDE DE LOIZA WATERSHED FECAL COLIFORM TMDLS

Introduction

The pollutant of concern for the fifteen LSPC subwatersheds and assessment units upstream of Lake Loiza is fecal coliform. The impaired water bodies covered under the TMDLs are classified as Class SD. The water quality standard for fecal coliform in surface waters, as stated in Section 3.2.4(B)(2) of the Puerto Rico Water Quality Standards Regulation (PRWQSR), As Amended, on March 2003 is:

> *"Coliforms: The coliform geometric mean of a series of representative samples (at least five samples) of the waters taken sequentially shall not exceed 10,000 colonies/100 mL of total coliform 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."*

Compliance with the fecal coliform standard will be applied based on 20 percent of the samples not exceeding 400 col/100 mL. This will be assessed using the calibrated fecal coliform watershed model, which was applied on a continuous basis from 2000-2004 (5 years). Load reductions will be determined such that the model calculated fecal coliform concentrations (on a daily basis) will not result in more than 20% of the concentrations exceeding the 400 col/100 mL standard (i.e., compliance with the standard 80% of the time as stated in the regulations). This also typically results in compliance with the fecal coliform geometric mean standard of 200 col/100 mL.

The designated use that has been established by the Environmental Quality Board for a Class SD water in Section 3.2.4(A) of the PRWQSR is stated below:

> *"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. Primary contact recreation is precluded in any stream or segment that does not comply with Section 3.2.4(B)12 of this article until such stream or segment meets the goal of the referred section."*

A conservative assumption made in many of these TMDLs is that fecal coliform loads which result from wastewater pumping station and collection system failures is assigned to the WWTPs to which they ultimately contribute their flows. This results in assignment of existing loadings in subwatersheds not containing a WWTP, which tends to overestimate the existing loadings from other sources such as failing septic systems and AFOs/pasture land. As a result, estimates of the load reductions necessary to achieve the nonpoint source LA within these TMDLs may be somewhat exaggerated. The Phase 1I program which has been proposed is designed to provide further insight into this matter.

Section IV of this report provides the detailed assumptions used to calculate the loads from the various pollutant sources within the Rio Grande de Loiza watershed. The point sources loadings include WWTPs and wastewater pumping station and collection system failures. The nonpoint source loads include urban runoff, animal feeding operations including pasture lands, failing septic systems, croplands and forested land. Table VI-1 provides the annual average fecal coliform loading for the 15 LSPC subwatersheds. The table presents fecal coliform loads specific to each LSPC segment. The cumulative effect of upstream sources on downstream LSPC segments is implicitly included in the model framework (i.e., the model is based on mass balances around each segment that include both internal and upstream loads).

Table V-2 identifies the Category 3 and 5 Assessment Units in each the 15 LSPC Watersheds.

1.0 RIO CAÑAS (1)

1.1 Identification of Assessment Unit/ Pollutant of Concern/Priority Ranking

The Rio Cañas (1) subwatershed is located in the northwestern portion of the Rio Grande de Loiza watershed and encompasses 6,633 acres (see Figure IV-1). There are no named lakes within this subwatershed. It does not contain any Category 5 Assessment Units (AU).

Table V-1

RIO GRANDE DE LOIZA WATERSHED
EXISTING FECAL COLIFORM LOADING
(NO. COLONIES/YEAR)

LSPC Subwatershed	NONPOINT SOURCE					POINT SOURCES		TOTAL		
	Cropland	AFO & Pasture	Forest	Urban	Septic	WWTP	Pump Station	NPS	PS	NPS + PS
Upper Loiza (13)	1.71E+12	4.15E+14	9.32E+12	1.60E+11	1.26E+15	0.00E+00	0.00E+00	1.69E+15	0.00E+00	1.69E+15
Upper Loiza (14)	5.38E+11	1.78E+14	1.93E+12	3.81E+10	3.31E+14	0.00E+00	0.00E+00	5.12E+14	0.00E+00	5.12E+14
Upper Loiza (12)	7.22E+12	2.86E+14	5.97E+12	2.45E+11	1.95E+15	5.05E+11	1.07E+14	2.25E+15	1.08E+14	2.36E+15
Turabo (11)	6.24E+12	3.34E+14	1.47E+13	3.72E+11	2.57E+15	1.86E+10	3.09E+13	2.93E+15	3.10E+13	2.96E+15
Caguitas (7)	4.37E+12	9.58E+13	4.20E+12	2.95E+11	2.78E+15	0.00E+00	0.00E+00	2.89E+15	2.13E+13	2.91E+15
Bairoa (5)	1.36E+12	3.24E+13	2.44E+12	1.05E+11	8.84E+14	9.14E+12	1.60E+15	9.21E+14	4.78E+13	9.68E+14
Cañas (1)	2.35E+12	3.86E+13	3.68E+12	1.15E+11	1.05E+15	0.00E+00	0.00E+00	1.09E+15	0.00E+00	1.09E+15
Gurabo (9)	4.99E+13	2.02E+14	5.81E+12	1.34E+11	1.39E+15	0.00E+00	0.00E+00	1.65E+15	0.00E+00	1.65E+15
Gurabo (10)	5.72E+11	2.04E+14	1.65E+12	1.37E+11	1.45E+15	1.06E+12	1.35E+14	1.66E+15	1.36E+14	1.79E+15
Gurabo (4)	1.38E+13	1.61E+14	4.21E+12	1.57E+11	1.65E+15	0.00E+00	0.00E+00	1.83E+15	0.00E+00	1.83E+15
Lower Loiza (8)	3.09E+12	1.32E+13	1.74E+11	8.20E+10	7.47E+14	0.00E+00	0.00E+00	7.64E+14	0.00E+00	7.64E+14
Lower Loiza (6)	2.06E+10	7.88E+11	8.21E+09	0.00E+00	5.18E+12	8.30E+12	1.54E+15	6.00E+12	1.55E+15	1.55E+15
Lower Loiza (3)	1.23E+11	1.85E+12	5.35E+10	3.70E+08	1.16E+13	0.00E+00	0.00E+00	1.37E+13	0.00E+00	1.37E+13
Lower Loiza (2)	5.92E+11	3.47E+13	7.30E+11	1.90E+10	1.80E+14	0.00E+00	0.00E+00	2.16E+14	0.00E+00	2.16E+14
Lago Loiza (15)	0.00E+00	2.30E+13	1.90E+12	3.40E+10	4.15E+14	0.00E+00	0.00E+00	4.40E+14	0.00E+00	4.40E+14

Table V-2

FECAL COLIFORM TMDL
LSPC SUBWATERSHEDS AND ASSESSMENT UNITS

LSPC Subwatersheds ( )*	Category 5 Assessment Units	Category 3 Assessment Units
Rio Canas (1)	None	Rio Canas (PRER01017_00)
Lower Loiza (2)	Lago Loiza (PREL0105_00)	None
Lower Loiza (3)	Lago Loiza (PREL0105_00)	None
Rio Gurabo (4)	Rio Gurabo (PRER0108b_00)	Rio Gurabo (PRER0108a_00) Rio Gurabo (PRER0108c_00)
Rio Bairoa (5)	Rio Bairoa (PRER0109b_00)	Rio Bairoa (PRER0109a_00) Rio Bairoa (PRER0109c_00)
Lower Loiza (6)	Lago Loiza (PREL0105_00)	Rio Grande de Loiza (PRER0110a_00)
Rio Caguitas (7)	Rio Grande de Loiza (PRER0110b_00)	Rio Grande de Loiza (PRER0110a_00) Rio Grande de Loiza (PRER0110c_00) Rio Caguitas (PRER0110d_00)
Lower Loiza (8)	Rio Grande de Loiza (PRER0110e_00)	Rio Grande de Loiza (PRER0110a_00)
Rio Gurabo (9)	None	Rio Gurabo (PRER0108d_00)
Rio Gurabo (10)	Rio Gurabo (Valenciano) (PRER0108h_02)	Rio Gurabo (PRER0108d_00)
Rio Turabo (11)	Rio Grande de Loiza (Turabo) (PRER0110f_02) Rio Grande de Loiza (Turabo) (PRER0110e_00)	Rio Turabo (PRER0110f_01) Rio Turabo (PRER0110g_00)
Upper Loiza (12)	Rio Grande de Loiza (PRER0110h_02) Rio Grande de Loiza (PRER0110e_00)	Rio Grande de Loiza (PRER0110h_01)
Upper Loiza (13)	None	Rio Grande de Loiza (PRER0110i_01) Rio Grande de Loiza (PRER0110k_00)
Upper Loiza (14)	Rio Grande de Loiza (Cayaguas) (PRER0110i_03)	Rio Grande de Loiza (PRER0110i_01)
Lago Loiza (15)	Lago Loiza (PREL0105_00)	Quebrada Caraizo (PREC0106_00)

*( ) LSPC Subwatershed number

It does, however, contain a Category 3 AU - PRER0107_00, Rio Cañas, which is 13.6 miles long. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

1.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Cañas and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

1.2.1 Assessment of Point Sources other than Storm Water

There are no point sources of fecal coliform loading within the Rio Cañas (1) subwatershed. Portions of this subwatershed are served by the Caguas WWTP. However, the Caguas WWTP discharges to the Rio Bairoa (5) subwatershed. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

1.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather, as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operation includes three horse farms and is identified in Table B-3.

Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

1.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 1-1 and depicted on Figure 1-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Rio Cañas (LSPC Segment 1), the sewered population is 7,206. The remaining population of 6,844 does not have sewage collection systems available.

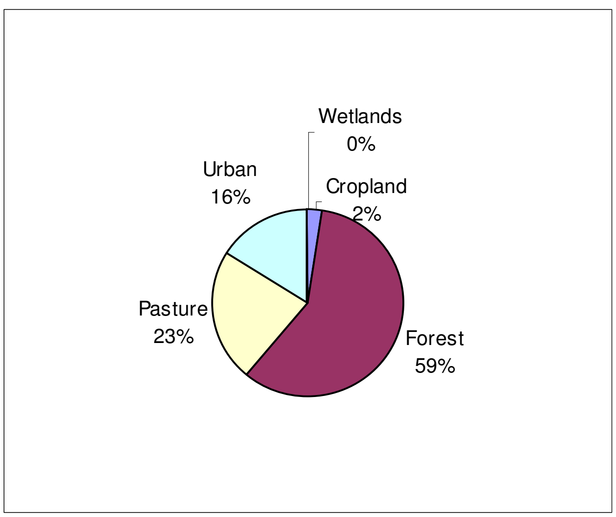
Table 1-1

SUBWATERSHED RIO CAÑAS (1)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	157
Forest	3,853
Pasture	1,552
Urban	1,071
Wetlands	0
TOTAL	**6,633**

Figure 1-1

SUBWATERSHED RIO CAÑAS (1)
LAND USE



Using the methodologies presented in Section 1.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the nonpoint sources for the Rio Cañas (1) subwatershed are repeated for convenience in

Table 1-2. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 1-2
POLLUTANT SOURCE LOADS

Source	Fecal Coliform Load (#colonies/yr)
Cropland	2.35 E+12
Pasture (AFOs)	3.86 E+13
Forest	3.68 E+12
Urban	1.15 E+11
Septic	1.05 E+15
Subtotal	*1.09 E+15*
WWTP	0.00E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**1.09 E+15**

The dominant existing fecal coliform loadings are septic system failures and pasture lands including animal feeding operations. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

1.4 Water Quality Analysis

As described in EPA Guidance, a TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

1.4.1 Surface Water Quality Data Overview

There are no water quality monitoring stations, either PREQB or USGS, located in the Rio Cañas (1) subwatershed. The fecal coliform loads were calculated based on runoff from the land use categories identified above (see Section 1.3).

1.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002)), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

1.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

1.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 1-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 13.48 E+10 #colonies/day. This TMDL consists of a WLA of 0 #colonies/day, a LA of 12.11 E+10#colonies/day and MOS of 0.49 E+13 1.25 E+10 #colonies/day, a 10% Margin of Safety.

The WLA is 0 #colonies/day in the Rio Cañas (1) subwatershed, since there are no point sources of fecal coliform loading. The loads from the sewered areas were assigned to the Caguas WWTP in the Rio Bairoa (5) subwatershed.

Although, it is not a regulatory requirement, Table 1-3 includes an individual LA for each category.

The achievement of the LA is addressed in Section 1-9.

Table 1-3 provides a summary of the current loads and the TMDL.

Table 1-3

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 1: Rio Canas	**Current Load (# colonies/yr)**	**Percent Reduction**	**Load Capacity (# colonies/yr)**	**TMDL (# colonies/day)**
Total Load	**1.09 E+15**	**95.9**	**4.92 E+13**	**13.48 E+10**
Explicit MOS = 10%	n/a	n/a	0.443 E+13	1.25+10
Waste Load Allocations*:				
WWTP or other NPDES source	0.00 E+00	0	0.00 E+00	0.00 E+00
Pump Station Bypass	0.0 0E+00	0	0.00 E+00	0.00 E+00
Load Allocations:				
Cropland	0.235 E+13	0	0.235 E+13	0.64 E+10
Pasture (AFOs)	3.86 E+13	90	0.386 E+13	1.05 E+10
Forest	0.368 E+13	0	0.368 E+13	1.00 E+10
Urban	0.0115 E+13	0	0.0115 E+13	0.03 E+10
Septic	1.05 E+15	96.7	3.43 E+13	9.39 E+10

*No NPDES permitted facilities (WWTPs, AFOs, Storm Water, etc)

1.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991

TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

There are no point source discharges to this subwatershed. However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

1.9 Implementation

Potential sources include flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 1.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent, an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 3.47 E+13 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 1.016 E+15 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

1.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. As part of Phase 2, a monitoring plan should be established and be conducted to assess the response of instream water quality as load reductions are made over time. This water quality monitoring plan should include a monitoring station within the Rio Cañas (1) subwatershed in order to meet this goal.

2.0 LOWER LOIZA (2)

2.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Lower Loiza (2) subwatershed is located in the central portion of the Rio Grande de Loiza watershed and encompasses 2,376 acres (see Figure 4-1). There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) - PREL0105_00, Rio Grande de Loiza, which is 713 acres in size is located within this subwatershed. This AU begins in the Lower Loiza (6) subwatershed and continues through the Lower Loiza subwatersheds (3) and (2), culminating in the Lago Loiza (15) subwatershed. There are no Category 3 AUs in the subwatershed. The impaired waters listing specifies the water quality problem as having a high priority. The pollutant of concern is fecal coliform.

2.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Grande de Loiza and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

2.2.1 Assessment of Point Sources other than Storm Water

There are no point sources of fecal coliform pollution within the Lower Loiza (2) subwatershed. Portions of this subwatershed are served by the Caguas WWTP. However, the Caguas WWTP discharges to the Rio Bairoa (5) subwatershed. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

2.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather, as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operations includes two horse farms and are identified in Table B-3. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program . Therefore, all urban runoff is considered as a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

2.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 2-1 and depicted on Figure 2-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Lower Loiza (LSPC Segment 2), the sewered population is 1,373. The remaining population of 1,557 does not have sewage collection systems available.

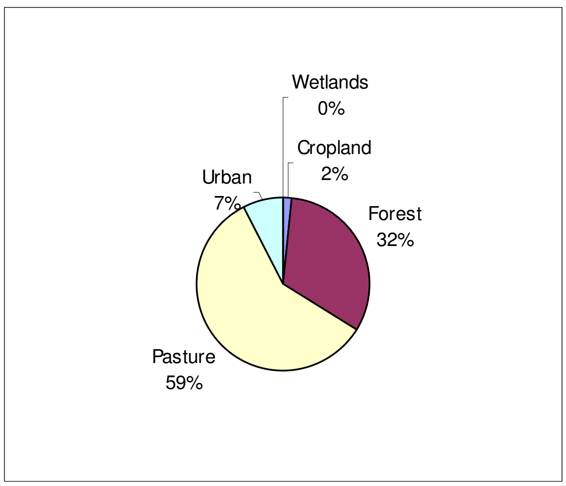
Table 2-1

SUBWATERSHED LOWER LOIZA (2)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	39
Forest	766
Pasture	1,395
Urban	176
Wetlands	0
TOTAL	**2,376**

Figure 2-1

SUBWATERSHED LOWER LOIZA (2)
LAND USE



Using the methodologies presented in Section 2.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the nonpoint sources for the Lower Loiza (2) subwatershed are repeated for convenience in Table 2-2. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 2-2
POLLUTANT SOURCE LOADS

Source	Fecal Coliform Load (#colonies/yr)
Cropland	5.92 E+11
Pasture (AFOs)	3.47 E+13
Forest	7.30 E+11
Urban	1.90 E+10
Septic	1.80 E+14
Subtotal	*2.16 E+14*
WWTP	0.00 E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**2.16 E+14**

The dominant existing fecal coliform loadings are septic system failures and pasture lands including animal feeding operations. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

2.4 Water Quality Analysis

As described in EPA Guidance, a TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round. Therefore, for a Phased TMDL, it is appropriate to express the TMDL on a yearly average basis. T.

2.4.1 Surface Water Quality Data Overview

There are no water quality monitoring stations, either PREQB or USGS, located in the Lower Loiza (2) subwatershed. The fecal coliform loads were calculated based on runoff from the land use categories identified above (see Section 2.3).

2.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002)), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

2.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

2.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 2-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 4.43 E+10 #colonies/day. This TMDL consists of a WLA of 0 #colonies/day, a LA of 3.975 E+10 #colonies/day and MOS of 0.44 E+10 #colonies/day, a 10% Margin of Safety.

The WLA is 0 #colonies/day in the Lower Loiza (2) subwatershed, since there are no point sources of fecal coliform loadings. The loads from the sewered areas were assigned to the Caguas WWTP in the Rio Bairoa (5) subwatershed.

Although, it is not a regulatory requirement, Table 2-3 includes an individual LA for each category.

The achievement of the LA is addressed in Section 2.9.

Table 2-3 provides a summary of the current loads and the TMDL.

Table 2-3

LAKE LOIZA TOTAL FECAL COLIFORM TMDL CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 2: Lower Loiza (2)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**2.16 E+14**	**93.3**	**1.62 E+13**	**4.43 E+10**
Explicit MOS = 10%	n/a	n/a	0.162 E+13	0.44 E+10
Waste Load Allocations*:				
WWTP or other NPDES source	0.00 E+00	0	0.00 E+00	0.00 E+00
Pump Station Bypass	0.0 0E+00	0	0.00 E+00	0.00 E+00
Load Allocations**:**				
Cropland	0.0592 E+13	0	0.0592 E+13	0.16 E+10
Pasture (AFOs)	0.347 E+14	90	0.347 E+13	0.93 E+10
Forest	0.073E+13	0	0.073E+13	0.20 E+10
Urban	0.0019E+13	0	0.0019E+13	0.005 E+10
Septic	1.80E+14	94.6	0.98E+13	2.68 E+10

*No NPDES permitted facilities (WWTPs, AFOs, Storm Water, etc)

2.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

There are no point source discharges to this subwatershed. However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

2.9 Implementation

Potential sources include flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 2.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent, an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 3.12 E+14 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 1.702 E+14 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

2.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. As part of Phase 2, a monitoring plan should be established and be conducted to assess the response of instream water quality as load reductions are made over time. This water quality monitoring plan should include a monitoring station within the Lower Loiza (2) subwatershed in order to meet this goal.

3.0 LOWER LOIZA (3)

3.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Lower Loiza (3) subwatershed is located in the central portion of the Rio Grande de Loiza watershed and encompasses 142 acres (see Figure 4-1). There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) - PREL0105_00, Lago Loiza , which is 713 acres in size, includes Lago Loiza and upstream portions of the Rio Grande de Loiza is located within this subwatershed. This AU begins in the Lower Loiza (6) subwatershed and continues through the Lower Loiza subwatersheds (3) and (2), culminating in the Lago Loiza (15) subwatershed. There are no Category 3 AUs in the subwatershed. The Puerto Rico 2004

303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority The pollutant of concern is fecal coliform.

3.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Grande de Loiza and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

3.2.1 Assessment of Point Sources other than Storm Water

There are no point sources of fecal coliform pollution within the Lower Loiza (3) subwatershed.

3.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather, as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

There are no AFOs in the Lower Loiza (3) subwatershed. Fecal coliform loadings are from runoff from the pasture lands.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

3.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 3-1 and depicted on Figure 3-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Lower Loiza (LSPC Segment 3), the entire population of 500 does not have sewage collection systems available.

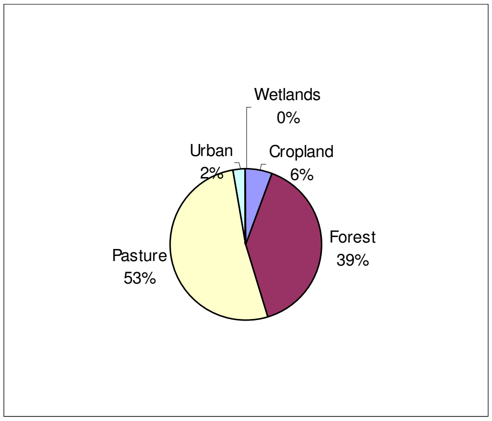
Table 3-1

SUBWATERSHED LOWER LOIZA (3)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	8
Forest	56
Pasture	75
Urban	3
Wetlands	0
TOTAL	**142**

Figure 3-1

SUBWATERSHED LOWER LOIZA (3)
LAND USE



Using the methodologies presented in Section 3.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the nonpoint sources for the Lower Loiza (3) subwatershed are repeated for convenience in Table 3-2. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 3-2

POLLUTANT SOURCE LOADS

Source	Fecal Coliform Load (#colonies/yr)
Cropland	1.23 E+11
Pasture (AFOs)	1.85 E+12
Forest	5.35 E+10
Urban	3.70 E+08
Septic	1.16 E+13
Subtotal	*1.36 E+13*
WWTP	0.00 E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**1.36 E+13**

The dominant existing fecal coliform loadings are septic system failures and pasture lands. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

3.4 Water Quality Analysis

As described in EPA Guidance, a TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

3.4.1 Surface Water Quality Data Overview

There are no water quality sampling stations within the Lower Loiza (3) subwatershed. The fecal coliform loads were calculated based on the runoff from the land use categories identified above (see Section 3.3)

3.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002)), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

3.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

3.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 3-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 2.43 E+9 #colonies/day. This TMDL consists of a WLA of 0 #colonies/day, a LA of 2.18 E+9 #colonies/day and MOS of 0.24 E+9 #colonies/day, a 10% Margin of Safety.

The WLA is 0 #colonies/day in the Lower Loiza (3) subwatershed, since there are no point sources of fecal coliform loadings.

Although, it is not a regulatory requirement, Table 3-3 includes an individual LA for each category.

The achievement of the LA is addressed in Section 3.9.

Table 3-3 provides a summary of the current loads and the TMDL.

Table 3-3

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 3: Lower Loiza (3)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**1.37 E+13**	**93.5**	**8.87 E+11**	**2.43 E+09**
Explicit MOS = 10%	n/a	n/a	0.887 E+11	0.24 E+09
Waste Load Allocations*:				
WWTP or other NPDES source	0.00 E+00	0	0.00 E+00	0.00 E+00
Pump Station Bypass	0.0 0E+00	0	0.00 E+00	0.00 E+00
***Load Allocations*:**				
Cropland	1.23 E+11	0	1.23 E+11	0.34 E+09
Pasture (AFOs)	1.85 E+12	90	1.85 E+11	0.50 E+09
Forest	0.535E+11	0	0.535 E+11	0.15 E+09
Urban	0.00370E+11	0	0.0037 E+11	0.001 E+09
Septic	1.16E+13	96.2	4.36 E+11	1.19 E+09

*No NPDES permitted facilities (WWTPs, AFOs, Storm Water, etc)

3.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

There are no point source discharges to this subwatershed. However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

3.9 Implementation

Potential sources include flows from failed/bypassed on-site sewage disposal systems, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 3.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Runoff from Pasture Lands

It is noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed;

stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. Additional monitoring must be conducted in the Lower Loiza (3) subwatershed, as well as initiating public outreach education regarding the recommended grazing controls

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 1.67 E+12 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 1.116 E+13 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

3.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. As part of Phase 2, a monitoring plan should be established and be conducted to assess the response of instream water quality as load reductions are made over time. This water quality monitoring plan should include a monitoring station within the Lower Loiza (3) subwatershed.

4.0 RIO GURABO (4)

4.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Rio Gurabo (4) subwatershed is located in the central portion of the Rio Grande de Loiza watershed and encompasses 13,246 acres (see Figure IV-1). There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) – PRER0108b_00, Rio Gurabo, which is 18.6 miles long, is located within this subwatershed. In addition, there are two Category 3 AUs, PRER0108a_00 at 10.9 miles and PRER0108c_00 at 25.9 miles in length, within this subwatershed. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

4.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Gurabo and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

4.2.1 Assessment of Point Sources other than Storm Water

Currently there is only one potential point source located within the subwatershed which is the water treatment plant (WTP). (Refer to Table 4-1.) This facility (Gurabo WTP) is currently operating without an NPDES permit. Fecal coliform loadings from a water treatment plant are not significant when compared to other sources. The other potential point source loadings are pump station failures and sanitary sewer overflows that contribute to the pollutant loading to the water column. The Gurabo WTP and PRASA sewage pumping stations were inspected to field verify their presence, as well as their operational characteristics. Loadings from sewage pumping stations and other collection system bypasses were estimated based upon the assumption that within the collection system of each WTP, raw sewage bypasses amounted to 1% of the WWTP flow volume. This assumption was arrived at after evaluation of bypass reports and records maintained by PRASA and EPA, and is believed reasonable for development of this Phase 1 TMDL. Portions of this subwatershed are served by the Caguas WWTP. However, the Caguas WWTP discharges to the Rio Bairoa (5) subwatershed. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

Table 4-1

POINT SOURCES

Facility Name	NPDES #	Map ID Number	Fecal Coliform (#/100 mL)	Total Coliform (#/100 mL)	Flow (mgd)	Receiving Water
Gurabo WTP	Not Available	NF2	Not Available	Not Available	Not Available	Rio Gurabo

4.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather, as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operation includes three horse farms and is identified in Table B-3. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

4.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 4-1 and depicted on Figure 4-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Rio Gurabo (LSPC Segment 4), the sewered population is 10,740. The remaining population of 22,132 does not have sewage collection systems available.

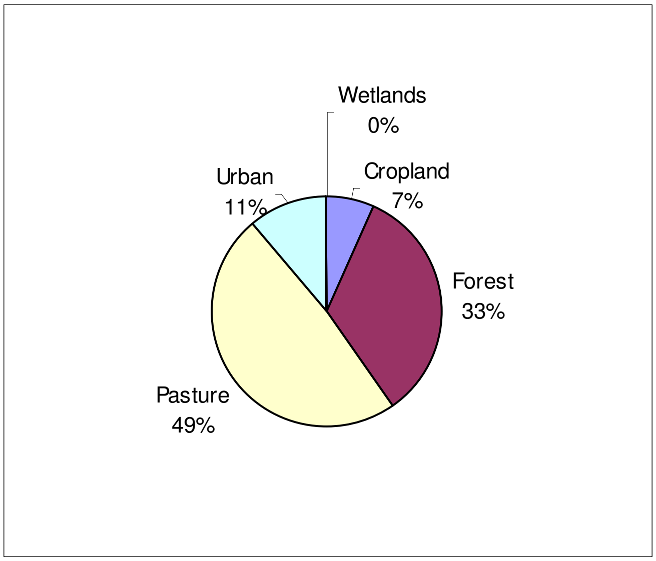
Table 4-1

SUBWATERSHED RIO GURABO (4)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	917
Forest	4,413
Pasture	6,456
Urban	1,460
Wetlands	0
TOTAL	**13,246**

Figure 4-1

SUBWATERSHED RIO GURABO (4)
LAND USE



Using the methodologies presented in Section 4.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the nonpoint sources for the Rio Gurabo (4) subwatershed are repeated for convenience in Table 4-2. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 4-2

POLLUTANT SOURCE LOADS

Source	**Fecal Coliform Load (#colonies/yr)**
Cropland	1.38 E+13
Pasture (AFOs)	1.61 E+14
Forest	4.21 E+12
Urban	1.57 E+11
Septic	1.65 E+15
Subtotal	*1.83 E+15*
WWTP	0.00 E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**1.83 E+15**

The dominant existing fecal coliform loadings are septic system failures and pasture lands. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

4.4 Water Quality Analysis

As described in EPA Guidance, a TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

4.4.1 Surface Water Quality Data Overview

The United States Geological Service (USGS) maintains the Water Quality Gage 50057025 (Station 4 on Figure IV-3), Rio Gurabo near Gurabo. USGS water quality data for fecal coliform and total coliform sampled at the gage are presented in chronological plot to show temporal and annual trends over the available time period (1997-2004). The Puerto Rico Environmental Quality Board (PREQB) fecal coliform and total coliform water quality data sampled at this gage over the time period (2001-2005) are also presented in chronological plot to show temporal and annual trends. Data are also presented as probability distributions to show compliance with water quality standards. Review of the USGS and EQB data (Figures A-4, A-9b, A-12 and A-19 in Appendix A) show the fecal coliform geometric mean and the 20 percentile water quality standard are substantially exceeded through 2003. However, PREQB's data from 2001 through 2003 shows a reduction in fecal coliform counts and no violations in 2004.

4.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002)), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

4.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

4.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 4-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 40.00 E+10 #colonies/day. This TMDL consists of a WLA of 0.0055 E+10 #colonies/day, a LA of 35.93 E+10 #colonies/yr. and MOS of 4.07 E+10 #colonies/day, approximately a 10% Margin of Safety.

All of the WLA (.0055 E+10 #colonies/day) is allocated to the Gurabo WTP. The WLA is based on a permit limit of 200 #colonies/100 ml being applied to the discharge and a wastewater flow of 0.050 mgd. The loads from the sewered areas were assigned to the Caguas WWTP in the Rio Bairoa (5) subwatershed.

Although, it is not a regulatory requirement, Table 4-3 includes an individual LA for each category.

The achievement of the LA is addressed in Section 4.9.

Table 4-3 provides a summary of the current loads and the TMDL.

Table 4-3

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 4: Rio Gurabo (4)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**1.83E+15**	**92.0**	**1.46 E+14**	**40.00 E+10**
Explicit MOS ~ 10%	n/a	n/a	0.146 E+14	4.07 E+10
Waste Load Allocations:				
WWTP or other NPDES source	deminimus			
Pump Station Bypass	0.0 0E+00	0	0.00 E+00	0.00 E+00
Load Allocations**:**				
Cropland	0.138E+14	0	0.138 E+14	3.78 E+10
Pasture (AFOs)	0.161E+15	90	0.16 E+14	4.39 E+10
Forest	0.0421E+14	0	0.0421 E+14	1.15 E+10
Urban	0.00157E+14	0	0.00157 E+14	0.04 E+10
Septic	1.65E+15	94.1	0.97 E+14	26.57 E+10

4.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

This nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support documents has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

4.9 Implementation

Potential sources include flows from failed/bypassed on-site sewage disposal systems, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 4.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Sewage Pumping Station Bypass Elimination

Implementation of an asset management program such as EPA's Voluntary Capacity Management Operation and Maintenance (CMOM) program aimed at eliminating these bypasses will eliminate any fecal coliform loads from this source.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste contamination structure failures from 10 to 1 percent, an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 1.45 E+14 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 15.53 E+14 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

4.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the USGS and PREQB at the USGS Gage 50057025 water quality monitoring station on the Rio Gurabo quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

5.0 RIO BAIROA (5)

5.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Rio Bairoa (5) subwatershed is located in the western portion of the Rio Grande de Loiza watershed and encompasses 4,927 acres. There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) PRER0109b_00, Rio Bairoa, which is 7.3 miles long, is located within this subwatershed. In addition, there are two Category 3 AUs, PRER0109a_00 at 5.2 miles and PRER0109c_00 at 3.8 miles in length, within this subwatershed. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

5.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Bairoa and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

5.2.1 Assessment of Point Sources other than Storm Water

Currently, there are five potential point sources located within the Rio Bairoa (5) subwatershed basin: three wastewater treatment plants (WWTP), one water treatment plant (WTP) and one municipal building (see Table 5-1). The other potential point source loadings are pump station failures and sanitary sewer overflows that contribute to the pollutant loading to the water column. The treatment plants and PRASA sewage pumping stations were inspected to field verify their presence, as well as their operational characteristics. Loadings from sewage pumping stations and other collection system bypasses were estimated based upon the assumption that within the collection system of each WWTP, raw sewage bypasses amounted to 1% of the WWTP flow volume. This assumption was arrived at after evaluation of bypass reports and records maintained by PRASA and EPA, and is believed reasonable for development of this Phase 1 TMDL. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

Table 5-1

POINT SOURCES

Facility Name	NPDES #	Map ID Number	Fecal Coliform (#/100 mL) *	Total Coliform (#/100 mL)*	Flow (mgd)	Receiving Water
Aguas Buenas WWTP	PR0020273	P1	2000, 2230 (8), 2-16793	10000, 22530 (8), 30-160000	0.6, 0.460 (12), 0.4-1.1	Rio Bairoa
Caguas WWTP	PR0025976	P2	2000, 70.04 (9), 3-256	N/A	12, 16.96 (11), 15.436-19.6	Rio Bairoa
Las Carolinas WWTP (1)	PR0024732	P4	2000, 16820.5 (8), 36-51897	10000, 73750 (8), 3000-160000	0.22, 0.3758 (12), 0.13-0.50	Rio Caguitas
Aguas Buenas WTP	PR0022896	PR1	2000, 2 (6), 2-2	10000, 15.33 (6), 2-80	.081, 0.0399 (8), .020-.135	Morena Creek
Mun. Govt-CTR Ops	PR0023426	NP5	2000, N/A (N/A), N/A	N/A	0.00240, .010 (12), .0028-.029	Rio Bairoa

(1) In August 2005, the Las Carolinas WWTP ceased discharging to the watershed and began pumping to the Caguas WWTP. Calculations for the TMDL will account for the Las Carolinas flow at the Caguas WWTP.

* Permit Limit, average discharge value (number of reported discharge values) range of discharge values.

5.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included septic system failures, runoff from pasture lands, forested areas, cropland and urban runoff.

Animal Feeding Operations/Grazing

There are no AFOs in the Rio Bairoa (5) subwatershed. Fecal coliform loadings are from runoff from the pasture lands.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

5.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 5-2 and depicted on Figure 5-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Rio Bairoa (LSPC Segment 5) the sewered population is 11,591. The remaining population of 2,202 does not have sewage collection systems available.

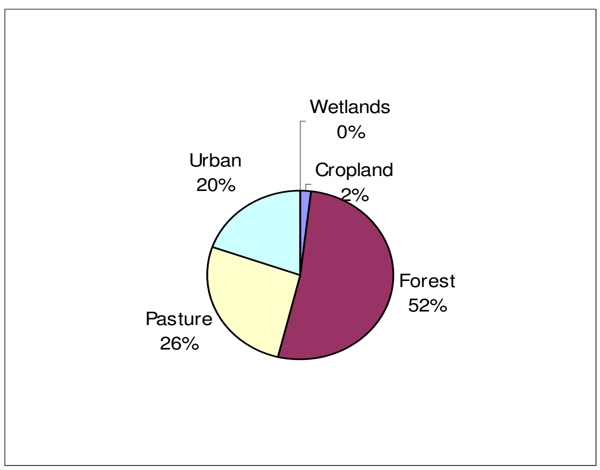
Table 5-2

SUBWATERSHED RIO BAIROA (5)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	91
Forest	2,557
Pasture	1,304
Urban	975
Wetlands	0
TOTAL	**4,927**

Figure 5-1

SUBWATERSHED RIO BAIROA (5)
LAND USE



Using the methodologies presented in Section 5.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the point and nonpoint sources for the Rio Bairoa (5) subwatershed are repeated for convenience in Table 5-3. The Point Sources loadings include WTPs and pump station failures. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 5-3

Pollutant Source Loads

Source	Fecal Coliform Load (#colonies/yr)
Cropland	1.36 E+12
Pasture	3.24 E+13
Forest	2.44 E+12
Urban	1.05 E+11
Septic	8.84 E+14
Subtotal	*9.21 E+14*
WWTP	9.14 0E+12
Pump Station	1.60 E+15
Subtotal	*1.61 E+15*
TOTAL	**2.53 E+15**

The dominant existing fecal coliform loadings are septic system failures and pump station/sanitary sewer overflows. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

5.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

5.4.1 Surface Water Quality Data Overview

The United States Geological Service (USGS) maintains the Water Quality Gage 50055400 (Station 3 on Figure IV-3), Rio Bairoa near Caguas. USGS water quality data for fecal coliform and total coliform sampled at the gage are presented in chronological plot to show temporal and annual trends over the available time period (1994-2004). The Puerto Rico Environmental Quality Board (PREQB) fecal coliform and total coliform water quality data sampled at this gage over the time period (2001-2005) are also presented in chronological plot to show temporal and annual trends. Data are also presented as probability distributions to show compliance with water quality standards. Review of the USGS and PREQB data (Figures A-1, A-7, A-12 and A-13 in Appendix A) show the fecal coliform geometric mean and the 20 percentile water quality standard are substantially exceeded through 2003. However, PREQB's data from 2001 through 2003 shows a reduction in fecal coliform counts and no violations in 2004.

5.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

5.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year-round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

5.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 5-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 31.23 E+10 #colonies/day. This TMDL consists of a WLA of 12.13 E+10 #colonies/day, a LA of 16.06 E+10 #colonies/day and MOS of 3.12 E+10 #colonies/day, a 10% Margin of Safety.

The WLA for the Aguas Buenas WWTP, Aguas Buenas WTP, and the Municipal Operations Center in Caguas were calculated using a permit limit of 200 #colonies/100 ml and the flow presented in Table 5-4. The remainder of the total WLA was allocated to the Caguas WWTP. At 24 mgd, the permit limit for the Caguas WWTP would be set at 130 #colonies/100 ml. This TMDL provides for trading and any transfer loads from the WWTPs in this subwatershed to the Caguas WWTP would result in an increase to the fecal permit coliform permit limit.

Table 5-4
WASTE LOAD ALLOCATION

Facility	Flow (mgd)	Fecal Coliform Load (#colonies/yr.)	Fecal Coliform Load (#colonies/day)
Aguas Buenas WWTP	0.6	0.196 E+13	0.53 E+10
Caguas WWTP	24	4.21 E+13	11.54 E+10
Aguas Buenas WTP	0.04	0.0132 E+13	0.04 E+10
Municipal Building	0.0024	0.0079 E+13	0.02E+10

Although, it is not a regulatory requirement, Table 5-5 includes an individual LA for each category.

The achievement of the WLA and LA are addressed in Section 5.9.

Table 5-5 provides a summary of current loads and the TMDL.

Table 5-5

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 5: Rio Bairoa (5)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**2.53E+15**	**95.4**	**11.4 E+13**	**31.23 E+10**
Explicit MOS = 10%	n/a	n/a	1.14 E+13	3.12 E+10
Waste Load Allocations:				
WWTP or other NPDES source	9.14E+12		4.43 E+13	12.13 E+10
Pump Station Bypass	1.60E+15	100	0.00 E+00	0.00 E+00
Load Allocations:				
Cropland	0.136E+13	0	0.136E+13	0.37 E+10
Pasture (AFOs)	3.24E+13	40	1.94E+13	5.31 E+10
Forest	0.244E+13	0	0.244E+13	0.66 E+10
Urban	0.0105E+13		0.0105E+13	0.03 E+10
Septic	8.84E+14	96	3.536 E+13	9.69 E+10

5.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

This nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

5.9 Implementation

Potential sources include wastewater treatment plants, water treatment plants, bypasses from wastewater pumping stations, sewer system overflows from sewer line breaks and stoppages, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 5.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Wastewater Treatment Plant Trading

PRASA plans to eliminate a number of small WWTPs and transfer their load to the 24 mgd Caguas WWTP. In order to account for the additional load that will eventually be reallocated to the Caguas WWTP, this TMDL provides for trading within the gross WLA. In this subwatershed, the Aguas Buenas WWTP is scheduled to be eliminated by November 2008 and the flow diverted to the Caguas WWTP. The Aguas Buenas WWTP load will be traded to the Caguas WWTP. EPA guidance (2003) indicates that a new TMDL is not required if the revised WLA results in equal or greater water quality improvements. EPA will be notified annually of any changes in the individual WLAs through trading. A revised TMDL will need be to be submitted and approved by EPA:

- if the load to be traded results in an increase in the gross Waste Load Allocation as identified by the TMDL in Table 5-5;
- if trading within the LAs is proposed; or
- if trading between the WLAs and LAs is proposed.

Sewage Pumping Station Bypass Elimination

Implementation of an asset management program such as EPA's Voluntary Capacity Management Operation and Maintenance (CMOM) program aimed at eliminating these bypasses will result in the elimination of 1.60 E+15 #colonies/yr.

Runoff from Pasture Lands

It was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization.

Additional monitoring must be conducted in the Rio Bairoa (5) subwatershed, as well as initiating public outreach and education regarding the recommended grazing controls.

Studies cited in the USEPA National Management Measures to Control Nonpoint Pollution from Agriculture have shown implementation of these measures result in a 40 percent reduction of instream fecal coliform. Implementation of these measures is estimated to result in an additional fecal coliform load reduction of 1.30 E+13 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 8.49 E+14 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

5.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the USGS and PREQB at the USGS Gage 5005540 water quality monitoring station on the Rio Bairoa quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

6.0 LOWER LOIZA (6)

6.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Lower Loiza (6) subwatershed is located in the central portion of the Rio Grande de Loiza watershed and encompasses 42 acres (see Figure 4-1). There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) PREL0105_00 Lago Loiza, which is 713 acres in size includes Lago Loiza and upstream portions of the Rio Grande de Loiza is located within this subwatershed. This AU begins in this subwatershed and continues through the Lower Loiza (3) and (2), culminating in the Lago (15) subwatershed. In addition, a portion of AU PRER011a_00 Rio Grande de Loiza is located in this subwatershed. This Category 3 AU originates in the Lower Loiza (8) subwatershed, flows through the Rio Caguitas (7) subwatershed, culminating in this subwatershed. It is 6.1 miles in length. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

6.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Grande de Loiza and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

6.2.1 Assessment of Point Sources other than Storm Water

There are no point sources of fecal coliform loadings within the Lower Loiza (6) subwatershed. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

6.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

There are no AFOs in the Lower Loiza (6) subwatershed. Fecal coliform loadings are from runoff from the pasture lands.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. . Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

6.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 6-2 and depicted on Figure 6-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Lower Loiza (LSPC Segment 6) the entire population of 300 does not have sewage collection systems available.

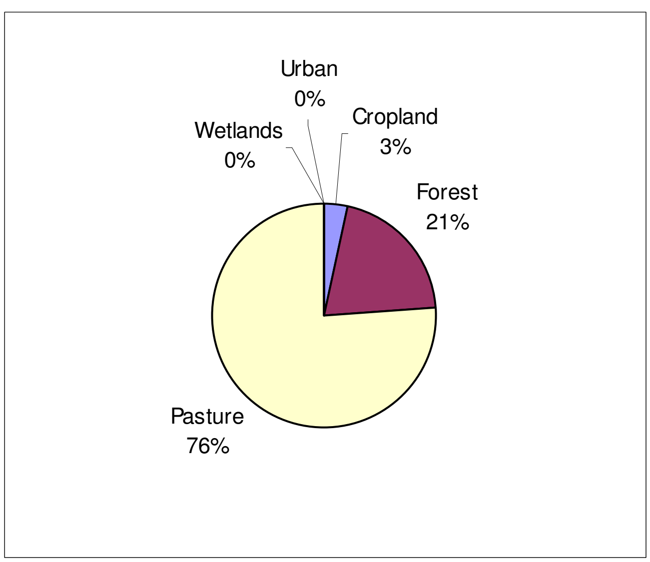
Table 6-1

SUBWATERSHED LOWER LOIZA (6)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	1
Forest	9
Pasture	32
Urban	0
Wetlands	0
TOTAL	**42**

Figure 6-1

SUBWATERSHED LOWER LOIZA (6)
LAND USE



Using the methodologies presented in Section 6.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the nonpoint sources for the Lower Loiza (6) subwatershed are repeated for convenience in Table 6-2 and include those associated with forested land, cropland, urban runoff and failing septic systems.

Table 6-2

Pollutant Source Loads

Source	**Fecal Coliform Load (#colonies/yr)**
Cropland	2.06 E+10
Pasture	7.88 E+11
Forest	8.21 E+09
Urban	0
Septic	5.18 E+12
Subtotal	*5.99 E +12*
WWTP	0.0 0E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**5.99 E+12**

The dominant existing fecal coliform loadings are septic system failures and pasture lands. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

6.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

6.4.1 Surface Water Quality Data Overview

There are no water quality sampling stations within the Lower Loiza (6) subwatershed. The fecal coliform loads were calculated based on the runoff from the land use categories identified above (see Section 6.3)

6.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% percent has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

6.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year-round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

6.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 6-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 9.86 E+08 #colonies/day. This TMDL consists of a WLA of 0 #colonies/day, a LA of 8.87 E+08 #colonies/day and MOS of 0.99 E+08 #colonies/day, a 10% Margin of Safety.

The WLA is 0 #colonies/day for the Lower Loiza (6) subwatershed since there are no point sources of fecal coliform loading within the subwatershed.

Although, it is not a regulatory requirement, Table 6-3 includes an individual LA for each category.

The achievement of the LA is addressed in Section 6-9.

Table 6-3 provides a summary of the current loads and the TMDL.

Table 6-3

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 6: Lower Loiza (6)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**5.99E+12**	**94.0**	**3.60 E+11**	**9.86 E+08**
Explicit MOS = 10%	n/a	n/a	0.36 E+11	0.99 E+08
Waste Load Allocations*:				
WWTP or other NPDES source	0.00 E+00	0	0.00 E+00	0.00 E+00
Pump Station Bypass	0.0 0E+00	0	0.00 E+00	0.00 E+00
***Load Allocations*:**				
Cropland	0.206E+11	0	0.206 E+11	0.56 E+08
Pasture (AFOs)	7.88E+11	90	0.788 E+11	2.16 E+08
Forest	0.0821E+11	0	0.0821 E+11	0.22 E+08
Urban	0.00E+00	0	0.00E+000	0.00 E+00
Septic	5.18E+12	95.8	2.164 E+11	5.93 E+08

*No NPDES permitted facilities (WWTPs, AFOs, Storm Water, etc.)

6.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

There are no point source discharges to this subwatershed. However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

6.9 Implementation

Potential sources include water treatment plants, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 14.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Runoff from Pasture Lands

It is noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. Studies cited in the USEPA National Management Measures to Control Nonpoint Pollution from Agriculture have shown normal implementation of these measures result in a 40 percent reduction of instream fecal coliform. These studies also have shown that when an alternate water supply was provided, the animal spent 90 percent less time in the stream. In this subwatershed intensive measures are need to be implemented to achieve a 90 percent reduction from the pasture lands.

Additional monitoring must be conducted in the Lower Loiza (6) subwatershed, as well as initiating public outreach and education regarding the recommended grazing controls.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 7.09 E+11 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 4.96 E+12 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

6.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. As part of Phase 2, a monitoring plan should be established and conducted to assess the response of instream water quality as load reductions are made over time. Water quality monitoring plan should include a monitoring station within the Lower Loiza (6) subwatershed in order to meet this goal.

7.0 RIO CAGUITAS (7)

7.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Rio Caguitas (7) subwatershed is located in the western portion of the Rio Grande de Loiza watershed and encompasses 11,291 acres (see Figure 4-1). There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) PRER0110b_00, Rio Grande de Loiza, which is 16.2 miles in length, is located within this subwatershed. In addition, there are three Category 3 AUs in this subwatershed. PRER0110a_00 Rio Grande de Loiza originates in the Lower Loiza (8) subwatershed, flows through this subwatershed, culminating in the Lower Loiza (6) subwatershed. It is 6.1 miles in length. PRER0110c_00 Rio Grande de Loiza at 3.8 miles in length and PRER0110d_00 Rio Caguitas at 10.7 miles in length are also located in this subwatershed. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

7.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Caguitas and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

7.2.1 Assessment of Point Sources other than Storm Water

Currently there is only one potential point source located within the Rio Caguitas (7) subwatershed basin, which is the Las Carolinas wastewater treatment plant (WWTP). In August 2005, the Las Carolinas WWTP ceased discharging to the Rio Caguitas (7) subwatershed and began pumping to the Caguas WWTP. So, now portions of this subwatershed are served by the Caguas WWTP. However, the Caguas WWTP discharges to the Rio Bairoa (5) subwatershed. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

7.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included septic system failures, runoff from pasture lands, forested areas, cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands.

The animal feeding operations include one hen and two horse operations and are identified in Table B-3. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

7.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in

Table 7-1 and depicted on Figure 7-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Rio Caguitas (LSPC Segment 7) the sewered population is 44,516. The remaining population of 23,146 does not have sewage collection systems available.

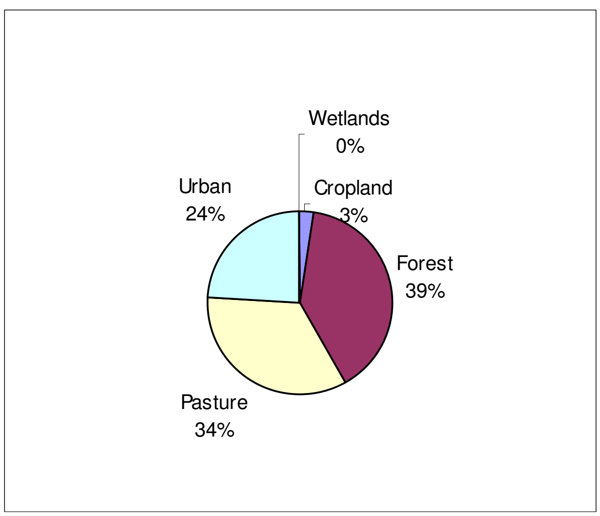
Table 7-2

SUBWATERSHED RIO CAGUITAS (7)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	291
Forest	4,407
Pasture (AFOs)	3,851
Urban	2,742
Wetlands	0
TOTAL	**11,291**

Figure 7-1

SUBWATERSHED RIO CAGUITAS (7)
LAND USE



Using the methodologies presented in Section 7.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the nonpoint sources for the Rio Caguitas (7) subwatershed are repeated for convenience in

Table 7-2. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, and urban runoff and failing septic systems.

Table 7-2

POLLUTANT SOURCE LOADS

Source	**Fecal Coliform Load (#colonies/yr)**
Cropland	4.37 E+12
Pasture(AFOs)	9.58 E+13
Forest	4.20 E+12
Urban	2.95 E+11
Septic	2.78 E+15
Subtotal	*2.89 E+15*
WWTP	0.00 E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**2.89 E+15**

The dominant existing fecal coliform loadings are septic system failures and pump station/sanitary sewer overflows. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

7.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

7.4.1 Surface Water Quality Data Overview

The United States Geological Service (USGS) maintains the Water Quality Gage 50055250 (Station 2 on Figure IV-3), Rio Caguitas at Highway 30 at Caguas. USGS water quality data for fecal coliform and total coliform sampled at this gage are presented in chronological plot to show temporal and annual trends over the available time period (2001-2004). The Puerto Rico Environmental Quality Board (PREQB) fecal coliform and total coliform water quality data sampled at this gage over the time period (2001-2005) are also presented in chronological plot to show temporal and annual trends. Data are also presented as probability distributions to show compliance with water quality standards. At this station, the probability plot shows that the 20% exceedance standard is violated greater than 98% of the time. Review of the USGS and PREQB data (Figures A-2, A-8, A-12 and A-13 in Appendix A) show the fecal coliform geometric mean and the 20 percentile water quality standard are substantially exceeded through 2003. However, PREQB's data from 2001 through 2003 shows a reduction in fecal coliform counts and no violations in 2004.

7.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

7.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year-round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor is the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

7.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that

50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 7-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 27.67 E+10 #colonies/day. This TMDL consists of a WLA of 0 #colonies/day, a LA of 24.91 E+10 #colonies/day and MOS of 2.76 E+10 #colonies/day, a 10% Margin of Safety.

Since there are no point sources of fecal coliform in this subwatershed, the WLA is 0 #colonies/day. The loads from the sewered areas were assigned to the Caguas WWTP in the Rio Bairoa (5) subwatershed.

Although, it is not a regulatory requirement, Table 7-4 includes an individual LA for each category.

The achievement of the LA is addressed in Section 7-9.

Table 7-4 provides a summary of the current loads and the TMDL.

Table 7-4

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 7: Rio Caguitas (7)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**2.89 E+15**	**96.5**	**10.1 E+13**	**27.67 E+10**
Explicit MOS = 10%	n/a	n/a	1.01 E+13	2.76 E+10
Waste Load Allocations*:				
WWTP or other NPDES source	0.00 E+00	0	0.00 E+00	0.00 E+00
Pump Station Bypass	0.0 0E+00	0	0.00 E+00	0.00 E+00
***Load Allocations*:**				
Cropland	0.437 E+13	0	0.437 E+13	1.20 E+10
Pasture (AFOs)	9.58 E+13	90	0.958 E+13	2.62 E+10
Forest	0.420 E+13	0	0.420 E+13	1.15 E+10
Urban	0.0295 E+13	0	0.0295 E+13	0.08 E+10
Septic	2.78 E+15	97.4	7.25 E+13	19.86 E+10

*No NPDES permitted facilities (WWTPs, AFOs, Storm Water, etc.)

7.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

There are no point source discharges to this subwatershed. However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

7.9 Implementation

Potential sources include water treatment plants, bypasses from wastewater pumping stations, sewer system overflows from sewer line breaks and stoppages, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 7.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent, an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 8.62 E+13 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 2.71 E+15 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

7.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the USGS at the USGS Gage 5005725 water quality monitoring station on the Rio Caguitas quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

8.0 LOWER LOIZA (8)

8.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Lower Loiza (8) subwatershed is located in the central portion of the Rio Grande de Loiza watershed and encompasses 1,682 acres (see Figure 4-1). There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) PRER0110e_00, Rio Grande de Loiza, which is 29 miles in length, culminates within this subwatershed. This AU is branched with one portion originating in the subwatershed Upper Loiza (12) and the other originating in the Turabo (11) subwatershed. In addition, a portion of AU PRER011a_00 Rio Grande de Loiza is located in this subwatershed. This Category 3 AU originates in this subwatershed, flows through the Rio Caguitas (7) subwatershed, culminating in the Lower Loiza (6) subwatershed. It is 6.1 miles in length. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

8.2 Source Assessment

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Grande de Loiza and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

8.2.1 Assessment of Point Sources other than Storm Water

There are no point sources of fecal coliform loadings within the Lower Loiza (8) subwatershed. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

8.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operation includes two horse farms and is identified in Table B-3. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

8.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 8-1 and depicted on Figure 8-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Lower Loiza (LSPC Segment 8), the entire population of 4,908 does not have sewage collection systems available.

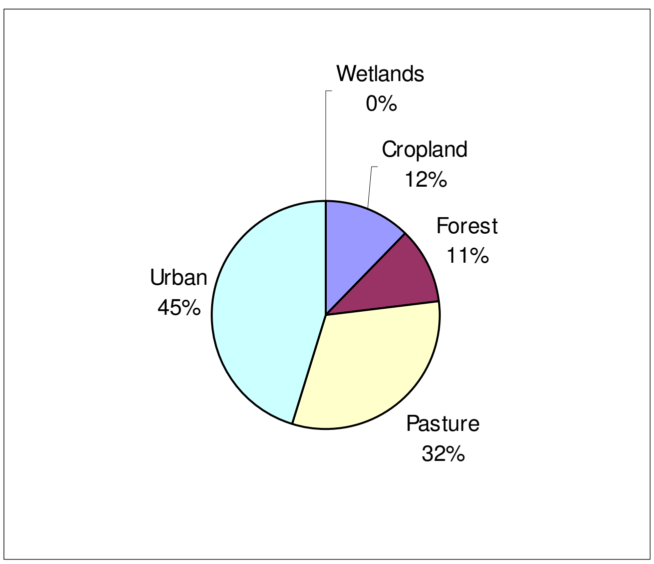
Table 8-1

SUBWATERSHED LOWER LOIZA (8)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	206
Forest	182
Pasture (AFOs)	531
Urban	763
Wetlands	0
TOTAL	**1,682**

Figure 8-1

SUBWATERSHED LOWER LOIZA (8)
LAND USE



Using the methodologies presented in Section 8.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the point and nonpoint sources for the Lower Loiza (8) subwatershed are repeated for convenience in Table 8-2. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 8-2

POLLUTANT SOURCE LOADS

Source	Fecal Coliform Load (#colonies/yr)
Cropland	3.09 E+12
Pasture (AFOs)	1.32 E+13
Forest	1.74 E+11
Urban	8.20 E+10
Septic	7.47 E+14
Subtotal	*7.64 E+14*
WWTP	0.0 0E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**7.64 E+14**

The dominant existing fecal coliform loadings are septic system failures and pasture lands including animal feeding operations. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

8.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

8.4.1 Surface Water Quality Data Overview

The United States Geological Service (USGS) maintains the Water Quality Gage 50055000 (Station 1 on Figure IV-3), Rio Grande de Loiza at Caguas. USGS water quality data for fecal coliform and total coliform sampled at this gage are presented in chronological plot to show temporal and annual trends over the available time period (1994-2004). The Puerto Rico Environmental Quality Board (PREQB) fecal coliform and total coliform water quality data sampled at this gage over the time period (2001-2005) are also presented in chronological plot to show temporal and annual trends. Data are also presented as probability distributions to show compliance with water quality standards. Review of the PREQB data (Figures A-3 and A-9a, A-12 and A-13 in Appendix A) show that the fecal coliform geometric mean and the 20 percentile water quality standard are substantially exceeded through 2000. However, PREQB's data from 2001 through 2003 shows only one violation but violations reoccurred in 2004.

8.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

8.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

8.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 8-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 15.29 E+10 #colonies/day. This TMDL consists of a WLA of 0 #colonies/day, a LA of 13.77 E+10 #colonies/day and MOS of 1.52 E+10 #colonies/day, a 10% Margin of Safety.

The WLA is 0 #colonies/day for the Lower Loiza (8) subwatershed since there are no point sources of fecal coliform loading within the subwatershed.

Although, it is not a regulatory requirement, Table 8-3 includes an individual LA for each category.

The achievement of the LA is addressed in Section 8-9.

Table 8-3 provides a summary of the current loads and the TMDL.

Table 8-3

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 8: Lower Loiza (8)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**7.64 E+14**	**92.7**	**5.558 E+13**	**15.29 E+10**
Explicit MOS = 10%	n/a	n/a	0.558 E+13	1.52 E+10
Waste Load Allocations*:				
WWTP or other NPDES source	0.00 E+00	0	0.00 E+00	0.00 E+00
Pump Station Bypass	0.0 0E+00	0	0.00 E+00	0.00 E+00
***Load Allocations*:**				
Cropland	0.309 E+13	0	0.309 E+13	0.85E+10
Pasture (AFOs)	1.32 E+13	90	0.132 E+13	0.36 E+10
Forest	0.0174 E+13	0	0.0174 E+13	0.05 E+10
Urban	0.0082 E+13	0	0.0082 E+13	0.02 E+10
Septic	7.47 E+14	93.9	4.56 E+13	12.49 E+10

*No NPDES permitted facilities (WWTPs, AFOs, Storm Water, etc.)

8.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

There are no point source discharges to this subwatershed. However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads have been made. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

8.9 Implementation

Potential sources include water treatment plants, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 8.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 1.19 E+13 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 5.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 7.014 E+14 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

8.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the USGS and PREQB at the USGS Gage 50055000 water quality monitoring station on the Rio Grande de Loiza quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

9.0 RIO GURABO (9)

9.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Rio Gurabo (9) subwatershed is located in the eastern portion of the Rio Grande de Loiza watershed and encompasses 19,390 acres (see Figure 4-1). There are no named lakes within this subwatershed. There are no Category 5 Assessment Units (AUs) within this subwatershed. There is one Category 3 AU - PRER0108d_00, Rio Gurabo, which is 37.7 miles in length. This AU originates in the Rio Gurabo (10) subwatershed and culminates in this subwatershed. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

9.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Gurabo and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

9.2.1 Assessment of Point Sources other than Storm Water

Currently, there is one potential point source located within the Rio Gurabo (9) subwatershed which is the Juncos WTP. (Refer to Table 9-1.) Fecal coliform loadings from a water treatment plant are not significant when compared to other sources such as sanitary sewer overflows. Portions of this subwatershed are served by the Juncos WWTP. However, the Juncos WWTP discharges to the Rio Gurabo (10) subwatershed. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

Table 9-1
POINT SOURCES

Facility Name	NPDES #	Map ID Number	Fecal Coliform (#/100 mL)	Total Coliform (#/100 mL)	Flow (mgd)	Receiving Water
Juncos WTP	PR0022811	PR6	200, N/A, (N/A), N/A		0.104, 0.086(1), 0.086-0.086	Rio Gurabo

* Permit limits, average discharge value (number of reported discharge values), range of discharge values.

9.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operations include three swine operations and one dairy, and are identified in Table B-3. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

9.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 9-2 and depicted on Figure 9-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Rio Gurabo (9), the sewered population is 13,894. The remaining population of 15,132 does not have sewage collection systems available.

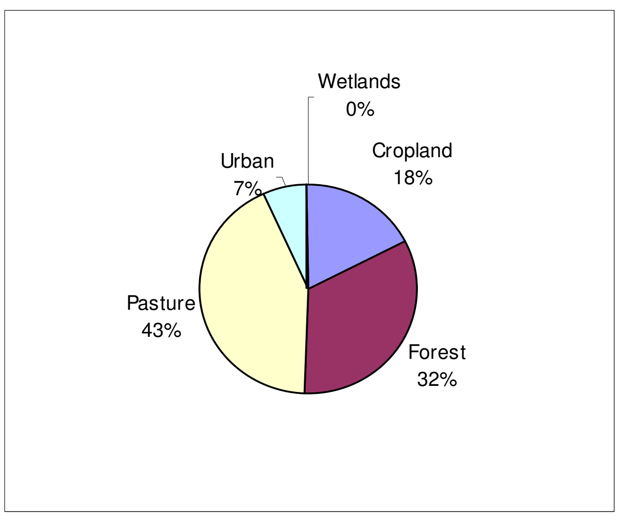
Table 9-2

SUBWATERSHED RIO GURABO (9)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	3,432
Forest	6,294
Pasture (AFOs)	8,370
Urban	1,281
Wetlands	0
TOTAL	**19,390**

Figure 9-1

SUBWATERSHED RIO GURABO (9)
LAND USE



Using the methodologies presented in Section 9.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the point and nonpoint sources for the Rio Gurabo (9) subwatershed are repeated for convenience in Table 9-3. The Point Source loading is from the Juncos WTP. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 9-3

POLLUTANT SOURCE LOADS

Source	Fecal Coliform Load (#colonies/yr)
Cropland	4.99 E+13
Pasture (AFOs)	2.02 E+14
Forest	5.81 E+12
Urban	1.34 E+11
Septic	1.39 E+15
Subtotal	*1.65 E+15*
WWTP	0.0 0E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**1.65 E+15**

The dominant existing fecal coliform loadings are septic system failures and pasture lands including animal feeding operations. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

9.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

9.4.1 Surface Water Quality Data Overview

There are no water quality sampling stations within the Rio Gurabo (9) subwatershed. The fecal coliform loads were calculated based on the runoff from the land use categories identified above (see Section 9.3)

9.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

9.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor is the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

9.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 9-2 in Appendix D presents the fecal coliform model output as a time series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 33.97 E+10 #colonies/day. This TMDL consists of a WLA of .0009 E+10 #colonies/day, a LA of 30.96 E+10 #colonies/day and MOS of 3.01 E+10 #colonies/day, approximately 10% Margin of Safety.

All of the WLA (.0009 E+10 #colonies/day) is allocated to the Juncos WTP. The WLA is based on a permit limit of 200 #colonies/100 mL being applied to the discharge and a wastewater flow of 0.105 mgd. The loads from the sewered areas were assigned to the Juncos WWTP in the Rio Gurabo (10) subwatershed.

Although, it is not a regulatory requirement, Table 9-4 includes an individual LA for each category.

The achievement of the WLA and LA are addressed in Section 9.9.

Table 9-4 provides a summary of the current loads and the TMDL.

Table 9-4

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 9: Rio Gurabo (9)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**1.65 E+15**	**92.5**	**1.24 E+14**	**33.97 E+10**
Explicit MOS ~ 10%	n/a	n/a	0.110 E+14	3.01 E+10
Waste Load Allocations:				
WWTP or other NPDES source	deminimus	0	0.00033 E+14	0.009 E+10
Pump Station Bypass	0.0 0E+00	0	0.00 E+00	0.00 E+00
Load Allocations:				
Cropland	0.499 E+14	0	0.499 E+14	13.67 E+10
Pasture (AFOs)	2.02 E+14	90	0.202 E+14	5.53 E+10
Forest	0.058 E+14	0	0.058 E+14	1.58 E+10
Urban	0.0013 E+14	0	0.013 E+14	0.35 E+10
Septic	1.39 E+15	97.4	0.359 E+14	9.84 E+10

9.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

There are no significant point source discharges to this subwatershed. However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads have been made. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

9.9 Implementation

Potential sources include water treatment plants, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 9.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 1.82 E+14 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.). These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 1.354 E+15 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

9.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. As part of Phase 2, a monitoring plan should be established and conducted to asses the response of instream water quality as load reductions are made over time. This water quality monitoring plan should include a monitoring station within the Rio Gurabo (9) subwatershed in order to meet this goal..

10.0 RIO GURABO (10)

10.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Rio Gurabo (10) subwatershed is located in the southeast portion of the Rio Grande de Loiza watershed and encompasses 11,605 acres (see Figure 4-1). There are no named lakes within this subwatershed. There is one Category 5 Assessment Unit (AU) PRER0108h_02, Rio Valenciano, within this subwatershed, and it is 6.9 miles in length. There is one Category 3 AU, PRER0108d_00, Rio Gurabo, which is 37.7 miles in length. This AU originates in this subwatershed and culminates in the Rio Gurabo (9) subwatershed. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

10.2 Pollutant Sources and Assessments

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Valenciano and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

10.2.1 Assessment of Point Sources other than Storm Water

There are five potential point sources located in the Rio Gurabo (10) subwatershed and are two wastewater treatment plants (WWTP), two water treatment plants (WTP) and one industrial storm water facility (see Table 10-1). Pump station failures and sanitary sewer overflows also contribute pollutant loading to the water column. For each facility, the following table provides the permit number, permit limits, average discharge value, number of reported discharge values, the range of 2004 discharge values for fecal coliform and total coliform, and the receiving water. Loadings from wastewater treatment plants were determined based upon evaluation of Discharge Monitoring Reports (DMRs) for the past three consecutive years. Each PRASA WWTP and sewage pumping station was inspected to field-verify its presence, as well as its operational characteristics. Loadings from sewage pumping stations and other collection system bypasses were estimated based upon the assumption that within the collection system of each WTP, raw sewage bypasses amounted to 1% of the WWTP flow volume. This assumption was arrived at after evaluation of bypass reports and records maintained by PRASA and EPA, and is believed reasonable for development of this Phase 1 TMDL. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

Table 10-1

POINT SOURCES

Facility Name	NPDES #	Map ID Number	Fecal Coliform (#/100 mL) *	Total Coliform (#/100 mL)*	Flow (mgd)	Receiving Water
Juncos WWTP	PR0020567	P3	2000, 29006 (8), 2-160000	10000, 90387 (8), 3-7160000	1.2, 1.70(12), 1.509-2.277	Rio Valenciano
Ceiba Sur WTP	PR0025119	PR4	2,000, 2 (2), 2-2		0.10, .059 (8), .03-.07	Rio Valenciano
Jagual San Lorenzo WTP	PR0025470	PR5	2000, 96 (2), 24-168	10000, 73750 (8), 3000-160000	0.042, 0.0218 (7), 0.0189-0.027	Quebrada Blanca Creek
Hersey Puerto Rico (formerly Life Savers) (storm water)	PR0023248	NP4	N/A	N/A	N/A, 4.29 (10), 0.117-16.251	Quebrada Sin Nom
S.U. Rivera Molina (school)	PR0024309	NP8	2000, 106 (9), 2-674	10000, 222 (9), 20-110	0.017, .0047 (9), .002-.015	Quebrada Valencio

* Permit limit, average discharge value, number of reported discharge values, and the range of 2004 discharge values.

10.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operations include one poultry operation and are identified in Table B-3.

Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

10.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for the Rio Gurabo (10) subwatershed is given in Table 10-2 and depicted on Figure 10-1. The unsewered population as compared to the total population for each of these subwatersheds is included in Table IV-8. For the Rio Gurabo (10) subwatershed, the sewered population is 6,215. The remaining population of 16.906 does not have sewage collections systems available.

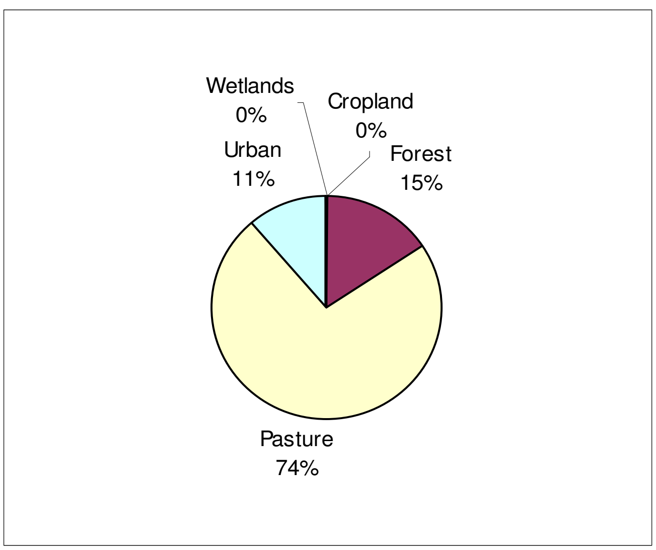
Table 10-2

SUBWATERSHED RIO GURABO (10)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	39
Forest	1,789
Pasture (AFOs)	8,461
Urban	1,315
Wetlands	0
TOTAL	**11,605**

Figure 10-1

SUBWATERSHED UPPER LOIZA (14)
LAND USE



Using the methodologies presented in Section 10.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the point and nonpoint sources for the Upper Loiza (14) subwatershed are repeated for convenience in Table 10-3. There are no Point Sources loadings except the small load from the PRASA Quebrada Arena WTP. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 10-3
POLLUTANT SOURCE LOADS

Source	**Fecal Coliform Load (#colonies/yr)**
Cropland	5.72 E+11
Pasture (AFO)	2.04 E+14
Forest	1.65 E+12
Urban	1.37 E+11
Septic	1.45 E+15
Subtotal	*1.66 E+15*
WWTP	1.06 E+12
Pump Station	1.35 E+14
Subtotal	*1.36 E+14*
TOTAL	**1.79 E+15**

The dominant existing fecal coliform loadings are septic system failures and pasture lands including animal feeding operations. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

10.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

10.4.1 Surface Water Quality Data Overview

The Puerto Rico Environmental Quality Board (PREQB) water quality data for fecal coliform and total coliform sampled at the PREQB Station L-1 (Rio Valenciano) are presented in chronological plot to show temporal and annual trends over the available time period (1997-2004). Data are also presented as probability distributions to show the state of compliance with water quality standards. Review of this data (Figures A-14 and A-19 in Appendix A) show the fecal coliform geometric mean and the 20 percentile water quality standard to be substantially exceeded. At this station, the probability plot shows that the 20% exceedance standard is violated greater than 40% of the time.

10.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

10.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

10.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 10-2 in Appendix D presents the fecal coliform model output as a time series from 2000-2004 for both existing and TMDL conditions.

The TMDL, WLAs, LAs and MOSs for this assessment unit is 24.54 E+10 #colonies/day. This TMDL consists of a WLA of 0.47 E+10 #colonies/day, a LA of 21.61 E+10 #colonies/day and MOS of 2.45 E+10 #colonies/day, a 10% Margin of Safety.

The WLA for the Ceiba Sur and the Jagual San Lorenzo WTPs, and S.U. Rivera Molina were calculated using a permit limit of 200 #colonies/100 mL and the flow presented in Table 10-4. The remainder of the total WLA was allocated to the Juncos WWTP. At 2.2 mgd, the permit limit for the Juncos WWTP would need to be 42 #colonies/100 mL in order for the WLA to be achieved. However, the Juncos WWTP is scheduled to be eliminated in November 2008 and the flow diverted to the Caguas WWTP. The WLA is allocated as follows (see Table 10-4):

Table 10-4
WASTE LOAD ALLOCATION

Facility	Flow (mgd)	Fecal Coliform Load (#colonies/day)
Juncos WWTP	2.2	0.35 E+10
Ceiba Sur WTP	0.10	0.076 E+10
Jagual San Lorenzo WTP	0.042	0.031 E+10
S.U. Rivera Molina	0.017	0.024 E+10

The Hersey-Puerto Rico NPDES permitted facility consists solely of storm water from the industrial area and does not have any coliform limits and, hence, is not allocated a load.

Although it is not a regulatory requirement, Table 10-5 includes an individual LA for each category.

The achievement of the WLA and LA are addressed in Section 10-9.

Table 10-5 provides a summary of the current loads and the TMDL.

Table 10-5

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 10: Rio Gurabo (10)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**1.79 E+15**	**95.0**	**8.96 E+13**	**24.54 E+10**
Explicit MOS = 10%			0.90 E+13	2.45 E+10
Waste Load Allocations:				
WWTP or other NPDES source	1.06 E+12	0	0.171 E+13	0.47 E+10
Pump Station Bypass	1.35 E+14	100	0.00 E+00	0.00 E+00
Load Allocations**:**				
Cropland	0.0572 E+13	0	0.0572 E+13	0.16 E+10
Pasture (AFOs)	2.04 E+14	90	2.04 E+13	5.59 E+10
Forest	0.165 E+13	0	0.165 E+13	0.45 E+10
Urban	0.0137 E+13	0	0.0137 E+13	0.04 E+10
Septic	1.45 E+15	96.1	5.61 E+13	15.37 E+10

10.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

This nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

10.9 Implementation

Potential sources include wastewater treatment plants, water treatment plants, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 10.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Wastewater Treatment Plant Controls

The Puerto Rico Aqueduct and Sewer Authority (PRASA) Capital Improvement Program includes projects to increase the Caguas WWTP capacity and to eliminate the Juncos WWTP and divert the wastewater to the Caguas WWTP. The Juncos WWTP is scheduled to be eliminated in November 2008. When the wastewater is diverted the WLA for the Juncos WWTP will be achieved.

Sewage Pumping Station Bypass Elimination

Implementation of an asset management program such as EPA's Voluntary Capacity Management Operation and Maintenance (CMOM) program aimed at eliminating these bypasses will result in the elimination of 1.35 E+14 #colonies/yr.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 1.84 E+14 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement of septic systems in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.). These failures result in overflows onto ground surfaces, which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed in order to allow the Rio Gurabo (10) subwatershed to comply with SD waters. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 1.3939 E+15 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

10.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the PREQB at its L-1 water quality monitoring station on the Rio Valenciano quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

11.0 RIO TURABO (11)

11.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Rio Turabo (11) subwatershed is located in the southwest portion of the Rio Grande de Loiza watershed and encompasses 18,599 acres (see Figure 4-1). There are no named lakes within this subwatershed. There are two Category 5 Assessment Units (AUs) within this subwatershed. The first is PRER0110f_02, Rio Turabo, with a length of 12.3 miles. The second is PRER0110e_00 Rio Turabo, with a length of 29 miles, which originates in this subwatershed and culminates in the Lower Loiza (8) subwatershed. There are two Category 3 AUs in this subwatershed – PRER0110f_01 Rio Turabo, with a length of 15.9 miles, and PRER0110g_00, with a length of 12.2 miles. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

11.2 Source Assessment

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Turabo and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

11.2.1 Assessment of Point Sources other than Storm Water

Currently, there are six potential point sources located in this subwatershed (see Table 11-1); one wastewater treatment plant (WWTP); two water treatment plants (WTP) and one industrial storm water facility with three permitted discharges. The other potential point source loadings are pump station failures and sanitary sewer overflows that contribute to the pollutant loading to the water column. The WWTPs, WTPs and PRASA sewage pumping stations were inspected to field verify their presence, as well as their operational characteristics. Loadings from sewage pumping stations and other collection system bypasses were estimated based upon the assumption that within the collection system of each WTP, raw sewage bypasses amounted to 1% of the WWTP flow volume. This assumption was arrived at after evaluation of bypass reports and records maintained by PRASA and EPA, and is believed reasonable for development of this Phase 1 TMDL. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

Table 11-1

POINT SOURCES

Facility Name	NPDES #	Map ID Number	Flow (mgd)	Receiving Water
Parcelas Borinquen WWTP	PR0025101	P5	0.30, 0.3472 (12), 0.22-0.566	Quebrada Arena
Caguas WTP	PR0022888	PR2	0.62, 0.17 (8), 0.14-0.297	Los Quebradullas Creek
San Salvador WTP	PR0026018	PR9	0.024, 0.00831 (7), 0.008 0.0102	Morena Creek
SP Pharmco 90 (1) (formerly SK&B) – C	PR0021997	NP9	0.162, N/A (N/A), N/A	QB Quebradillas
SP Pharmco 90 (1) (formerly SK&B) – D	PR0021997	NP10	0.162, N/A (N/A), N/A	QB Quebradillas
SP Pharmco 90 (1) (formerly SK&B) – E	PR0021997	NP11	0.162, N/A (N/A), N/A	QB Quebradillas

* Permit limit, average discharge value (number of reported discharge values), range of discharge values.

(1) Storm water discharge only.

11.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operations include two chicken and two swine operations and are identified in Table B-3. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

11.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds, as shown in Figure IV-1. Land use for this subwatershed is given in Table 11-2 and depicted on Figure 11-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Rio Turabo (LSPC Segment 11), the sewered population is 20,666. The remaining population of 17,884 does not have sewage collection systems available.

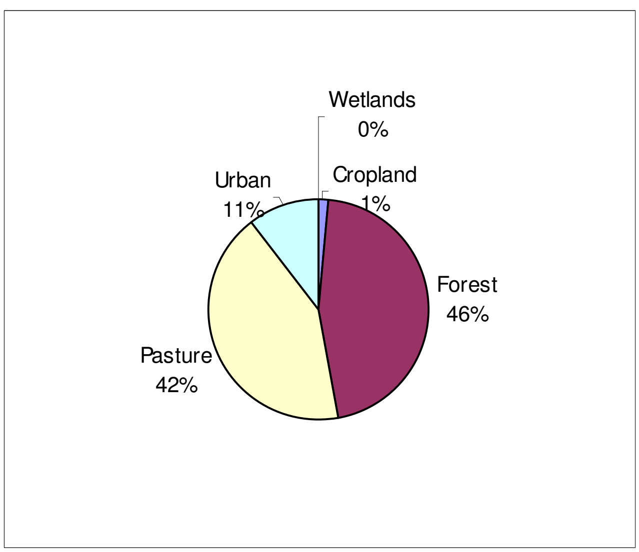
Table 11-2

SUBWATERSHED RIO TURABO (11)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	243
Forest	8,550
Pasture (AFOs)	7,343
Urban	1,976
Wetlands	0
TOTAL	**18,599**

Figure 11-1

SUBWATERSHED UPPER LOIZA (11)
LAND USE



Using the methodologies presented in Section 11.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the point and nonpoint sources for the Rio Turabo (11) subwatershed are repeated for convenience in Table 11-3. The Point Sources loadings include WWTP, WTPs and pump station failures. The nonpoint source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 11-3

POLLUTANT SOURCE LOADS

Source	**Fecal Coliform Load (#colonies/yr)**
Cropland	6.24 E+12
Pasture (AFOs)	3.34 E+14
Forest	1.47 E+13
Urban	3.72 E+11
Septic	2.57 E+15
Subtotal	*2.93 E+15*
WWTP	1.86 E+10
Pump Station	3.09 E+13
Subtotal	*3.11 E+13*
TOTAL	**2.96 E+15**

The dominant existing fecal coliform loadings are septic system failures, pasture lands including animal feeding operations and pump station/sanitary sewer overflows. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

11.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

11.4.1 Surface Water Quality Data Overview

The Puerto Rico Environmental Quality Board (PREQB) water quality data for fecal coliform and total coliform sampled at the PREQB Station L-5 (Rio Turabo) are presented in chronological plot to show temporal and annual trends over the available time period (1997-2004). Data are also presented as probability distributions to show compliance with water quality standards. Review of this data (Figures A-18 and A-19 in Appendix A) show the fecal coliform geometric mean and the 20 percentile water quality standard to be substantially exceeded. At this station, the probability plot shows that the 20% exceedance standard is violated greater than 50% of the time.

11.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

11.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

11.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that

50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 11-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 48.48 E+10 #colonies/day. This TMDL consists of a WLA of 0.43 E+10 #colonies/day, a LA of 43.14 E+10 #colonies/day and MOS of 4.85 E+10 #colonies/day, a 10% Margin of Safety.

The WLA for each point source is based on a permit limit of 200 #colonies/100 mL being applied to the discharge at the wastewater flow shown in Table 11-4.

Table 11-4
WASTE LOAD ALLOCATION

Facility	Flow (mgd)	Fecal Coliform Load (#colonies/yr)	Fecal Coliform Load (#colonies/day)
Parcelas Borinquen WWTP	0.30	0.099 E+13	0.27 E+10
Caguas WTP	0.17	0.056 E+13	0.15 E+10
San Salvador WTP	0.0083	0.0027 E+13-4	0.007 E+10

Although, it is not a regulatory requirement, Table 11-5 includes an individual LA for each category.

The achievement of the WLA and LA are addressed in Section 11-9.

Table 11-5 provides a summary of the current loads and the TMDL.

Table 11-5

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 11: Rio Turabo (11)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**2.96 E+15**	**94.0**	**17.7 E+13**	**48.48 E+10**
Explicit MOS = 10%	n/a	n/a	1.78 E+13	4.85 E+10
Waste Load Allocations:				
WWTP or other NPDES source	1.06 E+12		0.17 E+13	0.43 E+10
Pump Station Bypass	1.35 E+14	100	0.00 E+00	0.00 E+00
Load Allocations**:**				
Cropland	0.624 E+13	0	0.624 E+13	1.71 E+10
Pasture (AFOs)	3.34 E+14	90	3.34 E+13	9.15 E+10
Forest	1.47 E+13	0	1.47 E+13	4.02 E+10
Urban	0.0372 E+13	0	0.0372 E+13	0.10 E+10
Septic	2.57 E+15	96	10.28 E+13	28.16 E+10

11.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

This nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

11.9 Implementation

Potential sources include water treatment plants, bypasses from wastewater pumping stations, sewer system overflows from sewer line breaks and stoppages, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 11.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Wastewater Treatment Plant Controls

The Puerto Rico Aqueduct and Sewer Authority (PRASA) Capital Improvement Program includes projects to increase the Caguas WWTP capacity and to eliminate the Parcelas Borinquen WWTP and divert the wastewater to the Caguas WWTP. The Parcelas Borinquen WWTP is scheduled to be eliminated in August 2012. When the wastewater is diverted the WLA for the Parcelas Borinquen WWTP will be achieved.

Sewage Pumping Station Bypass Elimination

Implementation of an asset management program such as EPA's Voluntary Capacity Management Operation and Maintenance (CMOM) program aimed at eliminating these bypasses will eliminate any fecal coliform loads from this source.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 3.01 E+14 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.). These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 2.47 E+14 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

11.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the PREQB at its L-5 water quality monitoring station on the Rio Turabo quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

12.0 UPPER LOIZA (12)

12.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Upper Loiza (12) subwatershed is located in the central portion of the Rio Grande de Loiza watershed and encompasses 11,767 acres (see Figure 4-1). There are no named lakes within this subwatershed. There are two Category 5 Assessment Units (AUs) within this subwatershed. The first is PRER0110h_02, Rio Grande de Loiza, with a length of 11.9 miles.

The second is PRE0110e_00 Rio Grande de Loiza, with a total length of 29 miles which culminates in the Lower Loiza (8) subwatershed. This AU is branched with one portion originating in this subwatershed and the other originating in the Rio Turabo (11) subwatershed. There is one Category 3 AU in this subwatershed, PRER0110h_01, Rio Grande de Loiza, with a length of 15 miles. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

12.2 Source Assessment

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Grande de Loiza and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

12.2.1 Assessment of Point Sources other than Storm Water

There is three potential point sources located within the Upper Loiza (12) subwatershed which include one wastewater treatment plant (WWTP), one water treatment plant (WTP) and one school (see Table 12-1). Pump station failures and sanitary sewer overflows also contribute pollutant loading to the water column. For each facility, the following table provides the permit number, permit limits, average discharge value, number of reported discharge values, the range of 2004 discharge values for fecal coliform and total coliform, and the receiving water. Loadings from wastewater treatment plants were determined based upon evaluation of Discharge Monitoring Reports (DMRs) for the past three consecutive years. Each PRASA WWTP and sewage pumping station was inspected to field-verify its presence, as well as its operational characteristics. Loadings from sewage pumping stations and other collection system bypasses were estimated based upon the assumption that within the collection system of each WTP, raw sewage bypasses amounted to 1% of the WWTP flow volume. This assumption was arrived at after evaluation of bypass reports and records maintained by PRASA and EPA, and is believed reasonable for development of this Phase 1 TMDL. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

Table 12-1
POINT SOURCES

Facility Name	NPDES #	Map ID Number	Flow (mgd)	Receiving Water
San Lorenzo WWTP	PR0020834	P6	1.23, 1.10 (11), 0.87-1.85	Rio Grande de Loiza
San Lorenzo WTP	PR0022870	PR8	0.236, 0.201 (8), 0.150-0.250	Rio Grande de Loiza
PRPBA Espino	PR0024287	NP6		Rio Emajagua

* Permit limit, average discharge value (number of reported discharge values), range of discharge values.

12.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operations include one horse farm, two chicken and four swine operations, and one dairy farm, and is identified in Table B-3. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension

Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

12.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 12-2 and depicted on Figure 12-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Lower Loiza (LSPC Segment 12), the sewered population is 11,182. The remaining population of 26,827 does not have sewage collection systems available.

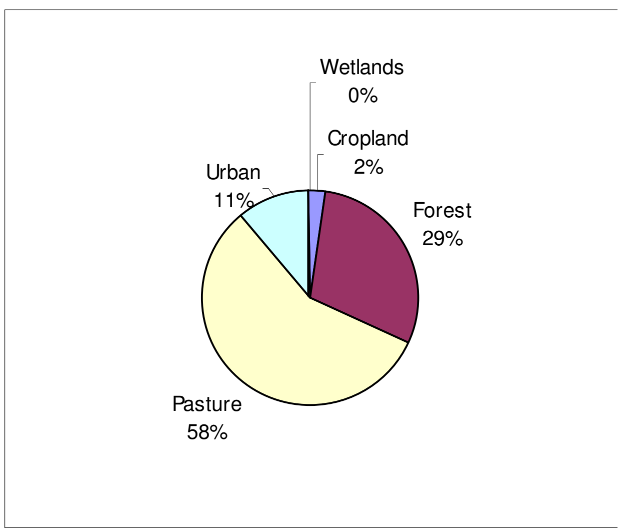
Table 12-2

SUBWATERSHED UPPER LOIZA (12)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	281
Forest	3,471
Pasture (AFOs)	6,715
Urban	1,300
Wetlands	0
TOTAL	**11.767**

Figure 12-1

SUBWATERSHED UPPER LOIZA (12)
LAND USE



Using the methodologies presented in Section 12.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the point and nonpoint sources for the Upper Loiza (12) subwatershed are repeated for convenience in Table 12-3. There are no Point Sources loadings except the small load from the PRASA Quebrada Arena WTP. The Nonpoint Source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 12-3

POLLUTANT SOURCE LOADS

Source	Fecal Coliform Load (#colonies/yr)
Cropland	7.22 E+12
Pasture (AFOs)	2.86 E+14
Forest	5.97 E+12
Urban	2.45 E+11
Septic	1.95 E+15
Subtotal	*2.25 E+15*
WWTP	5.05 E+11
Pump Station	1.07 E+14
Subtotal	*1.075 E+14*
TOTAL	**2.36 E+15**

The dominant existing fecal coliform loadings are septic system failures and pasture lands including animal feeding operations. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

12.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

12.4.1 Surface Water Quality Data Overview

The Puerto Rico Environmental Quality Board (PREQB) water quality data for fecal coliform and total coliform sampled at the PREQB Station L-2 (Rio Grande de Loiza) are presented in chronological plot to show temporal and annual trends over the available time period (1997-2004). Data are also presented as probability distributions to show compliance with water quality standards. Review of this data (Figures A-15 and A-19 in Appendix A) show the fecal coliform geometric mean and the 20 percentile water quality standard to be substantially exceeded. At this station, the probability plot shows that the 20% exceedance standard is violated greater than 60% of the time.

12.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

12.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

12.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that 50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 12-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 50.41 E+10 #colonies/day. This TMDL consists of a WLA of 2.02 E+10 #colonies/day, a LA of 43.44 E+10 #colonies/day and MOS of 4.95 E+10 #colonies/day, approximately a 10% Margin of Safety.

The WLA for each point source is based on a permit limit of 200 #colonies/100 mL being applied to the discharge and a wastewater flow as shown in Table 12-4.

Table 12-4

WASTE LOAD ALLOCATION

Facility	Flow (mgd)	Fecal Coliform Load (#colonies/yr)	Fecal Coliform Load (#colonies/day)
San Lorenzo WWTP	2.0	0.662 E+13	1.81 E+10
San Lorenzo WTP	0.236	0.078 E+13	0.21 E+10

Although, it is not a regulatory requirement, Table 12-5 includes an individual LA for each category.

The achievement of the WLA and LA are addressed in Section 12-9.

Table 12-5 provides a summary of the current loads and the TMDL.

Table 12-5

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 12: Upper Loiza (12)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**2.36 E+15**	**92.2**	**1.84 E+14**	**50.41 E+10**
Explicit MOS ~ 10%			0.181 E+13	4.95 E+10
Waste Load Allocations:				
WWTP or other NPDES source	1.86 E+10		0.74 E+13	2.02 E+10
Pump Station Bypass	3.09 E+13	100	0.00 E+00	0.00 E+00

Subwatershed 12: Upper Loiza (12)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
***Load Allocations*:**				
Cropland	0.072 E+14	0	0.072 E+14	1.97 E+10
Pasture (AFOs)	2.86 E+14	90	0.286 E+14	7.83 E+10
Forest	0.059 E+14	0	0.059 E+14	1.61 E+10
Urban	0.0024 E+14	0	0.0024 E+14	0.06 E+10
Septic	1.95 E+15	94	1.16 E+14	31.97 E+10

12.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

This nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

12.9 Implementation

Potential sources include wastewater treatment plants, water treatment plants, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 12.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

W*astewater Treatment Plant Controls*

The Puerto Rico Aqueduct and Sewer Authority (PRASA) Capital Improvement Program includes projects to increase the Caguas WWTP capacity and to eliminate the San Lorenzo WWTP and divert the wastewater to the Caguas WWTP. The San Lorenzo WWTP is scheduled to be eliminated in January 2009. When the wastewater is diverted the WLA for the San Lorenzo WWTP will be achieved.

Sewage Pumping Station Bypass Elimination

Implementation of an asset management program such as EPA's Voluntary Capacity Management Operation and Maintenance (CMOM) program aimed at eliminating these bypasses will eliminate any fecal coliform loads from this source.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent, an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 2.57 E+14 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.). These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 3.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 1.834 E+15 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

12.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the PREQB at the L-2 water quality monitoring station on the Rio Grande de Loiza quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

13.0 UPPER LOIZA (13)

13.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Upper Loiza (13) subwatershed is located in the southern portion of the Rio Grande de Loiza watershed and encompasses 16,507 acres (see Figure 4-1). There are no named lakes within this subwatershed. There are no Category 5 Assessment Units (AUs) within this subwatershed. There are two Category 3 AUs in this subwatershed. The first is PRER0110k_00, Rio Grande de Loiza, with a length of 24.3 miles. The second is PRER0110i_01, with a length of 12.7 miles, originates in this subwatershed and culminates in the Upper Loiza (14) subwatershed. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

13.2 Source Assessment

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Grande de Loiza and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

13.2.1 Assessment of Point Sources other than Storm Water

Currently, there are only three potential point sources located in the Upper Loiza (13) subwatershed (see Table 13-1), which include two water treatment plants (WTP) and one school. The WTPs (Quebrada Honda WTP and Espino WTP) are currently operating without an NPDES permit. Fecal coliform loadings from a water treatment plant and the school are not significant when compared to other sources. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

Table 13-1
POINT SOURCES

Facility Name	NPDES #	Map ID Number	Fecal Coliform (#/100 mL)	Total Coliform (#/100 mL)	Flow (mgd)	Receiving Water
Quebrada HondaWTP	Not Available	NF6	Not Available	Not Available	Not Available	Honda Creek
Espino WTP	Not Available	NF1	Not Available	Not Available	Not Available	Rio Emajagua
PRPBA Espino	PR0024287	NP6	200,286 (10), 2-2154	10000, 2145 (10), 2-12000	0.015, 0.011 (10), 0.07-0.015	Rio Emajagua

* Permit limit, average discharge value (number of reported discharge values), range of discharge values.

13.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operations include two chicken and two swine operations and are identified in Table B-3. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

13.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 13-2 and depicted on Figure 13-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Upper Loiza (RioCayaguas) (LSPC Segment 14), the total population of 5,785 is unsewered.

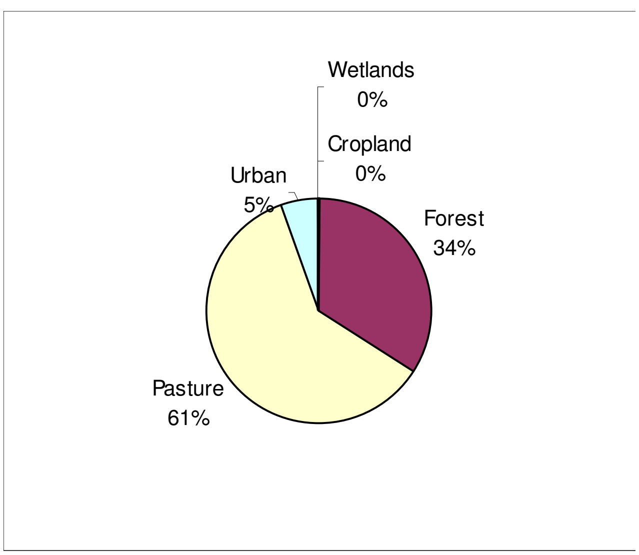
Table 13-2

SUBWATERSHED RIO TURABO (13)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	66
Forest	5,415
Pasture (AFOs)	9,728
Urban	848
Wetlands	0
TOTAL	**16,057**

Figure 13-1

SUBWATERSHED UPPER LOIZA (13)
LAND USE



Using the methodologies presented in Section 13.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the point and nonpoint sources for the Upper Loiza (13) subwatershed are repeated for convenience in Table 13-3. There are no Point Sources loadings except the infinitesimal load from the PRASA Quebrada Area WTP. The nonpoint source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 13-3
POLLUTANT SOURCE LOADS

Source	**Fecal Coliform Load (#colonies/yr)**
Cropland	1.71 E+12
Pasture (AFOs)	4.15 E+14
Forest	9.32 E+12
Urban	1.60 E+11
Septic	1.26 E+15
Subtotal	*1.69 E+15*
WWTP	0.00 E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**1.69 E+15**

The dominant existing fecal coliform loadings are septic system failures and pasture lands including animal feeding operations. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

13.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

13.4.1 Surface Water Quality Data Overview

The Puerto Rico Environmental Quality Board (PREQB) maintains the Water Quality Gage L-3 (Station 3 on Figure IV-1), Rio Grande de Loiza near San Lorenzo. The PREQB fecal coliform and total coliform water quality data sampled at this station over the time period (1997-2004) are presented in chronological plot to show temporal and annual trends. Data are also presented as probability distributions to show compliance with water quality standards. Review of the PREQB data (Figures A-16 and A-19 in Appendix A) show the fecal coliform geometric mean and the 20 percentile water quality standard are substantially exceeded through 2000. However, PREQB's data from 2000 through 2004 shows only one violation in 2003.

13.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

13.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

13.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that

50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 13-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 41.64 E+10 #colonies/day. This TMDL consists of a WLA of 0.11E+10 #colonies/day, a LA of 36.47 E+10 #colonies/day, and MOS of 5.06 E+14 #colonies/day, a 12% Margin of Safety.

The WLA is based on a permit limit of 200 #colonies/100 mL being applied to the discharge and a wastewater flow as shown in Table 13-4.

Table 13-4

WASTE LOAD ALLOCATION

Facility	Flow (mgd)	Fecal Coliform Load (#colonies/yr)	Fecal Coliform Load (#colonies/day)
Quebrada Honda WTP	0.006	0.000196 E+14	0.0053 E+10
PRPBA-Espino	0.015	0.000496 E+14	0.0136 E+10
Espino WTP	0.103	0.0033 E+14	0.091 E+10

Although, it is not a regulatory requirement, Table 13-5 includes an individual LA for each category.

The achievement of the WLA and LA are addressed in Section 13-9.

Table 13-5 provides a summary of the current loads and the TMDL.

Table 13-5

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 13: Upper Loiza (13)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**1.69 E+15**	**91.0**	**1.52 E+14**	**41.64 E+10**
Explicit MOS ~ 12%	n/a	n/a	0.185 E+14	5.06 E+10
Waste Load Allocations:				
WWTP or other NPDES source	deminimus		0.004 E+14	0.11 E+10
Pump Station Bypass	0.00 E+00		0.00 E+10	0.00 E+10
***Load Allocations*:**				
Cropland	0.017 E+14	0	0.017 E+14	0.46 E+10
Pasture (AFOs)	4.15 E+14	90	0.41 E+14	11.23 E+10
Forest	0.093 E+14	0	0.093 E+14	2.54 E+10
Urban	0.002 E+14	0	0.002 E+14	0.05 E+10
Septic	1.26 E+15	93.6	0.81 E+14	22.19 E+10

13.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

13.9 Implementation

Potential sources include water treatment plants, bypasses from wastewater pumping stations, sewer system overflows from sewer line breaks and stoppages, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 13.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 3.74 E+14 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.). These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 1.18 E+15 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

13.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the PREQB at the PREQB L-3 water quality monitoring station on the Rio Grande de Loiza near San Lorenzo quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

14.0 UPPER LOIZA (14)

14.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Upper Loiza (14) subwatershed is located in the southern portion of the Rio Grande de Loiza watershed and encompasses 5,525 acres (see Figure 4-1). There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) PRER0110i_03, Rio Grande de Loiza (Rio Cayaguas) which is 12.3 miles in length is located within this subwatershed. A Category 3 AU, PRER0110i_01, Rio Grande de Loiza originates the Upper Loiza (13) subwatershed culminating in this subwatershed, with a length of 12.7 miles. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

14.2 Source Assessment

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Rio Cayaguas and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

14.2.1 Assessment of Point Sources other than Storm Water

Currently there is only one potential point source located within the subwatershed which is the water treatment plants (WTP) existing within the Upper Loiza (Rio Cayaguas) subwatershed basin. This facility (Quebrada Arena WTP) is currently operating without an NPDES permit. Fecal coliform loadings from a water treatment plant are not significant when compared to other sources. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

Table 14-1

POINT SOURCES

Facility Name	NPDES #	Map ID Number	Fecal Coliform (#/100 mL)	Total Coliform (#/100 mL)	Flow (mgd)	Receiving Water
Quebrada Arena WTP	Not Available	NF5	Not Available	Not Available	Not Available	Quebrada Arena

14.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas, runoff from cropland and urban runoff.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. Based upon the type, number and grazing characteristics of animals present, a loading was established for each identified facility and a total loading from this category was calculated. Fecal coliform loadings were assumed associated with all designated pasture lands. The animal feeding operation includes one poultry operation and is identified in Table B-3.

Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

14.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 14-2 and depicted on Figure 14-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Upper Loiza (Rio Cayaguas) (LSPC Segment 14) the total population of 5,785 is unsewered.

Table 14-2

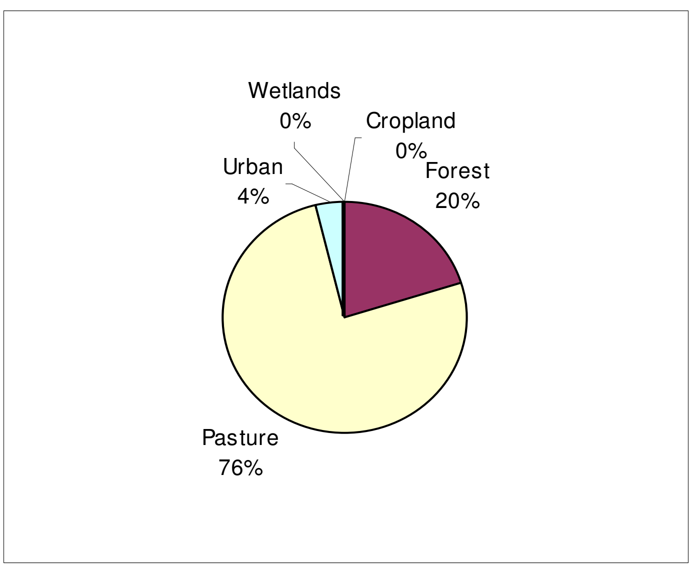
SUBWATERSHED UPPER LOIZA (14)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	21
Forest	1,120
Pasture (AFOs)	4,182
Urban	202
Wetlands	0
TOTAL	**5,525**

Figure 14-1

SUBWATERSHED UPPER LOIZA (14)

LAND USE



Using the methodologies presented in Section 14.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the point and nonpoint sources for the Upper Loiza (14) watershed are repeated for convenience in Table 14-3. There are no point sources loadings except the small load from the PRASA Quebrada Arena WTP. The nonpoint source loads include those associated with animal feeding operations, and associated with forested land, cropland, urban runoff and failing septic systems.

Table 14-3
POLLUTANT SOURCE LOADS

Source	**Fecal Coliform Load (#colonies/yr)**
Cropland	5.38 E+11
Pasture(AFOs)	1.78 E+14
Forest	1.93 E+12
Urban	3.81 E+10
Septic	3.31 E+14
Subtotal	*5.12 E+14*
WWTP	0.00 E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**5.12 E+14**

The dominant existing fecal coliform loadings are septic system failures and pasture lands including animal feeding operations. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

14.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

14.4.1 Surface Water Quality Data Overview

The Puerto Rico Environmental Quality Board (PREQB) maintains the Water Quality Gage L-4 (Station 4 on Figure IV-1), Rio Cayaguas near San Lorenzo. The PREQB fecal coliform and total coliform water quality data sampled at this station over the time period (1997-2004) are presented in chronological plot to show temporal and annual trends. Data are also presented as probability distributions to show compliance with water quality standards. Review of the PREQB data (Figures A-17 and A-19 in Appendix A) show that the fecal coliform geometric mean and the 20-percentile water quality standard are substantially exceeded through 2000. However, PREQB's data from 2000 through 2002 shows only one violation but violations reoccurred in 2003.

14.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

14.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

14.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that

50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 14-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 15.42 E+10 #colonies/day. This TMDL consists of a WLA of 0.0078 E+10#colonies/day, a LA of 13.81 E+10 #colonies/day and MOS of 1.60 E+10 #colonies/day, a 10% Margin of Safety.

All of the WLA (.0.0078 E+10 #colonies/yr.) is allocated to the Quebrada Arena WTP. The WLA is based on a permit limit of 200 #colonies/100 mL being applied to the discharge and a wastewater flow of 0.0086 mgd.

Although, it is not a regulatory requirement, Table 14-4 includes an individual LA for each category.

The achievement of the WLA and LA are addressed in Section 14-9.

Table 14-4 provides a summary of the current loads and the TMDL.

Table 14-4

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 14: Upper Loiza (14)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**5.17 E+14**	**89.1**	**5.63 E+13**	**15.42 E+10**
Explicit MOS ~ 10%	n/a	n/a	0.580 E+13	1.60 E+10
Waste Load Allocations:				
WWTP or other NPDES source	deminimus		0.00285 E+13	0.0078 E+10
Pump Station Bypass	0.00 E+00		0.00 E+00	0.00 E+00
Load Allocations:				
Cropland	0.05 E+13	0	0.05 E+13	014 E+10

Subwatershed 14: Upper Loiza (14)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Pasture (AFOs)	1.80 E+14	90	1.80 E+13	4.93 E+10
Forest	0.20 E+13	0	0.20 E+13	0.54 E+10
Urban	0.004 E+13	0	0.004 E+13	0.01 E+10
Septic	3.31 E+14	90.9	2.99 E+13	8.19 E+10

14.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

This nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

14.9 Implementation

Potential sources include water treatment plants, flows from failed/bypassed on-site sewage disposal systems, animal feeding operations/grazing operations, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 14.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Animal Feeding Operation/Grazing Controls

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of fecal coliform loadings to the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization. To reduce waste containment structure failures from 10 to 1 percent, an aggressive outreach and inspection program needs to be implemented to ensure waste containment structures are properly located and maintained.

Implementation of these recommendations could reduce the fecal coliform load from these sources by 90%. The estimated reduction is, therefore, an annual average of 1.62 E+14 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.). These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 5.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 3.01 E+14 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

14.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the PREQB at the PREQB L-4 water quality monitoring station on the Rio Cygus quarterly. These efforts will continue to track water quality improvements and to assure that the fecal water quality standard is achieved.

15.0 LAGO LOIZA (15)

15.1 Identification of Assessment Unit/Pollutant of Concern/Priority Ranking

The Lago Loiza (15) subwatershed is located in the northwestern portion of the Rio Grande de Loiza watershed and encompasses 3,234 acres (see Figure 4-1). There are no named lakes within this subwatershed. The Category 5 Assessment Unit (AU) PREL0105_00, Rio Grande de Loiza, which is 713 acres in size, is located within this subwatershed. This AU begins in the Lower Loiza (6) subwatershed and continues through the Lower Loiza subwatersheds (3) and (2), culminating in this subwatershed. One Category 3 AU is located within this watershed. It is the PREC0106_00 Quebrada Carraizo, with a length of 3 miles. The Puerto Rico 2004 303(d) list ranks fecal coliform impairment within the Loiza watershed as a high priority. The pollutant of concern is fecal coliform.

15.2 Pollutant Sources and Assessment

Source assessments are warranted in order to evaluate and characterize fecal coliform loading to the Lago Loiza and propose proper management responses. Source assessments include evaluation of all significant sources and their relative contributions to the fecal coliform loadings. A watershed model using the Loading Simulation Program in C++ (LSPC) has been utilized to estimate loadings.

15.2.1 Assessment of Point Sources other than Storm Water

There are no point sources of fecal coliform in the Lago Loiza (15) subwatershed. In addition, municipalities in Puerto Rico have not yet implemented a permitted storm water pollution control program. Therefore, there is no point source load attributed to urban storm water.

15.2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Sources evaluated for which loads have been assigned included animal feeding operations and grazing (AFOs), septic system failures, runoff from forested areas and urban runoff.

Animal Feeding Operations/Grazing

There are no AFOs in the Lago Loiza (15) subwatershed. Fecal coliform loadings are from runoff from the pasture lands.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined and applied with a septic tank failure rate of 50% and a flow of 50 gallons per capita per day (50 GPCD) and a fecal concentration of 1e6 #/mL to estimate the fecal loadings from this source. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Runoff from Forested Areas and Cropland

Analysis of land use based upon 1991 ERDAS was performed to determine the acreage of forest land, cropland, wetland, etc. Established runoff fecal coliform loadings per acre for each category were then calculated. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

Urban Runoff

Municipalities in Puerto Rico have not currently implemented permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source. Loadings were determined based upon standard runoff loadings for municipal storm water. Section IV-3 of this report provides the parameters and methodology utilized to develop the pollutant loads from this source.

15.3 Fecal Coliform Loadings by Source

Land use within the Rio Grande de Loiza watershed is depicted on Figure IV-2. For purposes of assigning loads to different streams within the watershed, the watershed was divided into 15 subwatersheds as shown in Figure IV-1. Land use for this subwatershed is given in Table 15-1 and depicted on Figure 15-1. The unsewered population as compared to the total population for each of these subwatersheds is shown on Table IV-8. For Lago Loiza (LSPC Segment 15), the entire population of 8,119 does not have sewage collection systems available.

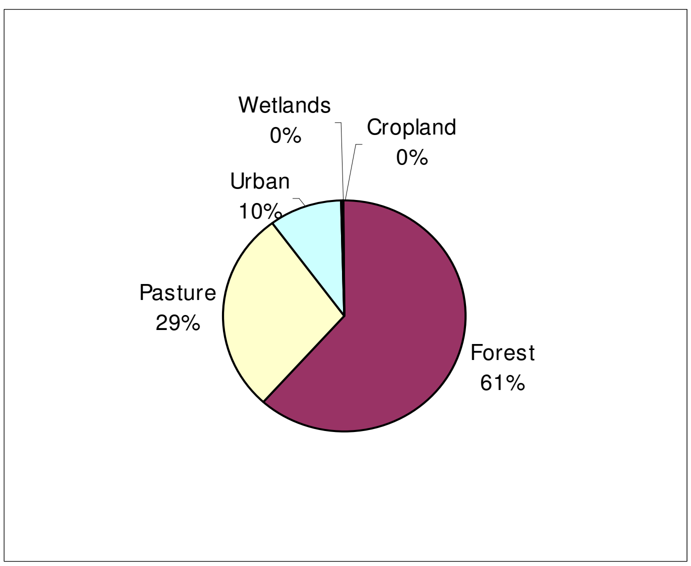
Table 15-1

SUBWATERSHED UPPER LOIZA (15)
LAND USE

Land Use Type	Land Use (Acres)
Cropland	0
Forest	1,989
Pasture	923
Urban	316
Wetlands	0
TOTAL	**3,234**

Figure 15-1

SUBWATERSHED LAGO LOIZA (15)
LAND USE



Using the methodologies presented in Section 15.2, fecal coliform loadings from each source category in this subwatershed were calculated. The existing fecal coliform loadings from the nonpoint sources for the Lago Loiza (15) subwatershed are repeated for convenience in Table 15-2. The Nonpoint Source loads include those associated with pasture land, forested land, urban runoff and failing septic systems.

Table 15-2

POLLUTANT SOURCE LOADS Source	**Fecal Coliform Load (#colonies/yr)**
Cropland	0.00 E+0
Pasture (AFOs)	2.30 E+13
Forest	1.90 E+12
Urban	1.40 E+10
Septic	4.15 E+14
Subtotal	*4.40 E+15*
WWTP	0.00 E+0
Pump Station	0.00 E+0
Subtotal	*0.00 E+0*
TOTAL	**4.40 E+14**

The dominant existing fecal coliform loadings are septic system failures and runoff from pasture lands. Implementing controls for these major sources will be critical in achieving the TMDL and water quality standards.

15.4 Water Quality Analysis

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violation of water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). The best management practices and other control measures to be implemented in this TMDL operate year round.

15.4.1 Surface Water Quality Data Overview

The United States Geological Service (USGS) maintains the Water Quality Gage 50059000 (Station 5 on Figure IV-3), Lago Loiza at dam site near Trujillo Alto. USGS water quality data for fecal coliform and total coliform sampled at this gage are presented in chronological plot to show temporal and annual trends over the available time period (1994-2004). Review of this data (Figures A-5, A-10, A-12, A-13) as compared to the water quality data at the other sampling stations indicates that, contrary to the other stations, bacteria at the Lago Loiza dam site is substantially lower due to the significant bacterial die-off in Lago Loiza.

15.5 Margin of Safety

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS. A MOS of 10% has been established to account for lack of knowledge concerning load and waste load, and water quality. It is common modeling practice to assign a 10% explicit MOS when there are no significant model biases as was the case in the model calibration. That is, there were no consistent over- or under-predictions of the data by the model. In addition, the overall percent difference between the model and data for the hydrology calibration was +/-5%.

15.6 Seasonal Variations/Critical Conditions

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, heavy rainfall events occur during all seasons such that fecal coliform loadings from all identified sources occur year round. While there may be some variability on a year-to-year basis due to weather pattern variability, it is not predictable enough nor are the impacts known with such certainty as would affect the model projections upon which the TMDL is based.

From a modeling perspective, the watershed model used to develop the fecal coliform loadings is a continuous calculation using rainfall patterns from 2000-2004 (5 years). This period experienced the typical seasonal patterns of rainfall, runoff and stream flow (i.e., both wet and dry events/seasons) and to this extent the TMDL modeling accounts for seasonal variations. For the fecal coliform TMDL, the critical condition can be both wet weather events (e.g., runoff from urban, pasture or agriculture) and average to dry weather conditions due to potential bacteria sources from pump station failures and failing septic systems. The approach used to assess compliance (reducing fecal coliform loads so that 80% of the concentrations are less than the 400 col/100 mL standard) considers a whole range of environmental conditions and, therefore, the TMDL analysis accounts for both wet and dry loading conditions.

15.7 Phase 1 TMDL Allocation

In order to develop the fecal coliform TMDL, the calibrated watershed model was used to determine the load reductions necessary to achieve 80% compliance with the fecal coliform standard of 400 col/100 mL as stated in the Puerto Rico water quality regulations. That is, the model loads were reduced so that the daily model output during the 5-year calibration period (2000-2004) resulted in compliance with the 400 col/100 mL standard 80% of the time. The load reductions were determined by analyzing the existing model daily output as probability distributions for each of the 15 subwatersheds in the basin (Appendix D, Figure 1) and then calculating the percent reduction necessary to achieve compliance with the 400 col/100 mL standard 80% of the time. The existing fecal coliform concentrations in this figure are presented as the solid line and the TMDL concentrations as the dashed line. This figure also highlights that

50% of the time the TMDL load reductions will also achieve the geometric mean standard of 200 col/100 mL.

Details of the fecal coliform watershed model development, calibration and load determination are presented in Section IV in addition to the cause and effect relationship between bacteria loads and instream fecal coliform concentrations. The resulting reduced loadings needed to comply with the standard constitute the TMDLs for which WLAs, LAs and MOSs were then produced. Figure 15-2 in Appendix D presents the fecal coliform model output as a time-series from 2000-2004 for both existing and TMDL conditions.

A Phase 1 TMDL is 9.40 E+10 #colonies/day. This TMDL consists of a WLA of 0 #colonies/day, a LA of 8.46 E+10 #colonies/day and MOS of 0.94 E+10 #colonies/day, a 10% Margin of Safety.

The WLA is 0 #colonies/day for the Lago Loiza (15) subwatershed since there are no point sources of fecal coliform.

Although, it is not a regulatory requirement, Table 15-3 includes an individual LA for each category.

The achievement of the LA is addressed in Section 15-9.

Table 15-3 provides a summary of the current loads and the TMDL.

Table 15-3

LAKE LOIZA TOTAL FECAL COLIFORM TMDL
CURRENT LOADS/TMDL/WLA/LA/MOS

Subwatershed 15: Lago Loiza (15)	Current Load (# colonies/yr)	Percent Reduction	Load Capacity (# colonies/yr)	TMDL (# colonies/day)
Total Load	**4.40 E+14**	**92.2**	**3.43 E+13**	**9.40 E+10**
Explicit MOS ~ 10%	n/a	n/a	0.343 E+13	0.94 E+10
Waste Load Allocations:				
WWTP or other NPDES source	0.00 E+00		0.00 E+00	0.00 E+00
Pump Station Bypass	0.00 E+00		0.00 E+00	0.00 E+00
Load Allocations**:**				
Cropland	0.00 E+00		0.00 E+00	0.00 E+00
Pasture (AFOs)	2.30 E+13	40	1.38 E+13	3.78 E+10
Forest	0.19 E+13		0.19 E+13	0.52 E+10
Urban	0.0014 E+13		0.0014 E+13	0.004 E+10
Septic	4.15 E+14	96.3	1.516 E+13	4.15 E+10

15.8 Reasonable Assurance

When a TMDL is developed for waters impaired by both point and nonpoint sources, and the WLA is based on an assumption that nonpoint source load reductions will occur, EPA's 1991 TMDL Guidance states that the TMDL should provide reasonable assurances that nonpoint source control measures will achieve expected load reductions in order for the TMDL to be approvable. Exceedances of fecal coliform criteria within this watershed are nonpoint source driven. With respect to point sources of fecal coliform, each WWTP that discharges to the Loiza watershed, has a NPDES permit that includes a fecal coliform limit and the requirement to disinfect its effluent.

There are no point source discharges to this subwatershed. However, this nonpoint source based TMDL includes an implementation plan that includes management recommendations for reductions of nonpoint source loads. This TMDL represents the most feasible TMDL for implementation. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The Phase 1 TMDL support document has proposed an aggressive implementation plan which includes: nonpoint source management plans; best management practices (BMPs), to reduce urban and agricultural sources; and a monitoring plan, which will evaluate fecal coliform levels, monitor loadings of point and nonpoint sources, evaluate and assess the effectiveness of BMPs and recommend the implementation of additional BMPs, as necessary. Furthermore, the TMDL includes a monitoring plan to evaluate the effectiveness of nonpoint source controls and to reevaluate, as necessary, fecal coliform reduction measures.

The TMDL, including the load and waste load allocations, has been established at a level necessary to implement water quality standards.

15.9 Implementation

Potential sources include flows from failed/bypassed on-site sewage disposal systems, runoff form forested lands, cropland and pastures, and urban storm water runoff. Section 15.3 provides the loadings from these sources. To achieve the TMDL, implementation of the management options below are needed to control bacterial contamination to achieve/maintain the water quality standard.

Pasture Lands

Recommended grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; and improved manure management practices to ensure proper placement and stabilization

Studies cited in the USEPA National Management Measures to Control Nonpoint Pollution from Agriculture have shown implementation of these measures result in a 40 percent reduction of instream fecal coliform. Implementation of these recommendations could reduce the fecal coliform load from these sources by 40%. The estimated reduction is, therefore, an annual average of 0.92 E+13 #colonies/yr.

Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but, again, a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.). These failures result in overflows on to ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 2.0% is needed. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

Reduction of the failure rate is estimated to result in an additional fecal coliform load reduction of 3.99 E+14 #colonies/yr.

Runoff from Forested Area and Cropland

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL.

Urban Runoff

No Best Management Practices (BMPs) need to be implemented to achieve the Phase 1 TMDL. However, implementation of BMPs as proposed in EPA's Draft permit will further reduce the fecal coliform from this source.

15.10 Monitoring

A phased approach to implementation is appropriate for fecal coliform TMDLs, considering the highly variable nature of nonpoint source pollutant loads. As part of Phase 2,a monitoring plan should be established and conducted to assess the response of instream water quality as load reductions are made over time. This water quality monitoring plan should include a monitoring station within the Lago Loiza (15) subwatershed in order to meet this goal.

VI. RIO GRANDE DE LOIZA WATERSHED COPPER TMDLS

1.0 IDENTIFICATION OF ASSESSMENT UNIT/POLLUTANT OF CONCERN/ PRIORITY RANKING

The assessment units are the Rio Caguitas (PRER0110b_00) and Rio Bairoa (PRER0109b_00). The length of the Rio Caguitas and Rio Bairoa are 16.2 and 7.3 miles, respectively. The pollutant of concern is copper. The impaired waters listing for each specifies the water quality problem as having a high priority. These impaired waters are classified as Class SD. The water quality standard for copper in these surface waters, as stated in Section 3.1.9(A), Specific Standards for Inorganic Substances, of the Puerto Rico Water Quality Standards Regulation (PRWQSR), As Amended, on March 2003 is:

> *The maximum allowable concentration of these specific substances in coastal, surface, estuarine and groundwater shall not exceed the following at any specific time: Copper (surface water) - Concentration in ug/l must not exceed the numerical value given by* $e^{(0.8545[\ln Hardness]-1.702)}$.

The designated use that has been established by the Environmental Quality Board for Class SD water in Section 3.2.4 (A) of the PRWQSR is stated below:

> "*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. Primary contact recreation is precluded in any stream or segment that does not comply with Section 3.2.4(B)12 of this article until such stream or segment meets the goal of the referred section.*"

2.0 POLLUTANT SOURCES AND ASSESMENTS

Source assessments are warranted in order to evaluate and characterize copper loadings to the Rio Bairoa and Rio Caguitas and propose proper management responses. Source assessments include evaluation of all significant point sources and their relative contributions to the total copper loadings, and calculation of total nonpoint source loadings.

2.1 Assessment of Point Sources other than Storm Water

The major point sources on these streams were the Las Carolinas WWTP, and the Aguas Buenas WWTP, as well as attendant wastewater pumping stations. The Aguas Buenas Water

Treatment Plant (WTP) is located on a creek upstream of the Rio Bairoa. The NPDES effluent permit limits, permit number, 2004 discharge values, location and receiving water are presented in Table VI-1.

Table VI-1

NPDES PERMIT LIMITS

Facility Name	NPDES #	Map ID Number	Flow (mgd)	Copper (ug/L)*	Receiving Water
Aguas Buenas WWTP	PR0024732	P1	0.60	17, 27 (7), 5-51	Rio Bairoa
Aguas Buenas WTP	PR0022896	PR1	0.081	15, 16.6(9), 5-41	Morena Creek
Las Carolinas WWTP	PR0024731	Ceased Discharge (8/2005)	0.22	20, 28(10), 10-51	Rio Caguitas
Limit Type			Daily Max	Daily Max	

*Permit limit, average discharge value (number of reported discharge values), range of discharge values.

The pump station bypass load of copper is estimated to be 1% of the WWTP flow and the WWTP permit limit ([lbs/day] = 0.01 x flow [mgd] x 8.43 x concentration [mg/L]). Because pump station bypass is illegal and will be address through NPDES compliance enforcement, the TMDL load for pump station bypass of copper equals 0.0 ug/L.

2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Nonpoint sources include septic system failures, urban runoff and for this analysis wastewater pumping station failures and sewer system overflows.

As discussed in Section IV, The Rio Grande de Loiza watershed was delineated into 15 subwatersheds (see Figure IV-1). The two streams being analyzed here are located within LSPC segments 5 (Rio Bairoa), and 7 (Rio Caguitas). It should be noted that each of the subwatershed areas is greater than the drainage area of the listed assessment unit.

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined.

Table VI-2
SEWERED/UNSEWERED POPULATION

LSPC Segment	Total Population	Sewered Population	Unsewered Population	% Unsewered
5	13,793	11,591	2,202	16
7	67,662	44,516	23,146	34

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore, all urban runoff is considered a nonpoint source.

3.0 WATER QUALITY ANALYSIS

As described in EPA Guidance, A TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). For a copper TMDL, it is appropriate to express the TMDL on a daily basis. Daily pollutant loadings are more critical to the river during low flow conditions, especially during the 7Q2 critical stream flow.

3.1 Surface Water Quality Data Overview

The United States Geological Service (USGS) maintains Water Quality Stations 50055400 (Station 3 on Figure IV-1, Rio Bairoa near Caguas) and 50055250 (Station 2 on Figure IV-1, Rio Caguitas at HWY 30 at Caguas). Probability plots of USGS data from 1994 to 2004 and PREQB data from 2001 to 2005 for these two stations are presented in Figure A-58. Since the copper water quality standard is dependent on hardness, the criterion is indicated for a hardness of 50 and 100 mg/l. For copper, the water quality standards are 5.16 and 9.33 ug/l and are represented by the dashed lines. Review of the USGS and PREQB data presented in these figures show most measurements are at detection levels. However, in Rio Bairoa and Rio Caguitas some measurements are above the detection levels indicating an exceedance of the water quality criterion at a hardness level of 100 mg/l. Based on observed receiving water hardness data, a median hardness value of 100 mg/L is typical for Rio Bairoa and Rio Caguitas and will be used for the TMDL calculations. This hardness results in a copper water quality standard of 9.33 ug/L.

In October 2005, the United States Environmental Protection Agency (EPA) conducted copper sampling of the Aguas Buenas WWTP and Caguas WWTP effluents and in the receiving stream, upstream and downstream of the discharge point. Sampling was performed utilizing clean techniques in EPA Method 1669, "Sampling Ambient Water for Trace metals at EPA Water Quality Criteria Levels." The prescribed sampling methods are specifically designed to provide a level of protection to preclude sample contamination during collection, transport and analysis. The analytical method used for copper was EPA-200.7, Inductively Coupled Plasma Optical Emission Spectrometry, which achieves a detection level of 0.294 ug/l. EPA's report, dated November 22, 2005, states the following:

> *"Copper, at concentration of 0.513 ug/l was detected in the field blank. Where copper was also detected in a sample at a concentration less than five times the concentration detected in the blank, the result was qualified "B." The "B" qualifier indicates that contamination may make up an uncertain proportion of the result for that sample. There is confidence that the true value for the qualified sample is less than the value given, but the exact value is uncertain. Where the concentration of copper detected in a sample is more than five times the blank value, the data are not qualified and may be used without restriction."*

The EPA sampling results are provided in Table VI-3.

Table VI-3
EPA SAMPLING RESULTS

Sample Location	Hardness (mg/l)	Total Copper (ug/l)
Aguas Buenas-Upstream	130	<2.37 B
Aguas Buenas-Downstream	120	4.82
Aguas Buenas WWTP-Effluent	120	2.33 B
Caguas-Upstream	140	<2.38 B
Caguas-Downstream	125	3.67
Caguas WWTP -Effluent	110	<2.14 B

This sampling event, even though only for one day and not at low flow conditions, reveals that the water quality criteria in the Rio Bairoa was not violated and both wastewater treatment plants did not violate the copper discharge limit.

3.2 Water Quality Load Calculation

The pollutant, copper, is considered to be a conservative pollutant where instream impacts are associated at the point of discharge. To determine the allowable loadings to these streams, a simple dilution mass balance calculation at the point of discharge is suitable to determine the waste load allocation necessary to meet the water quality standard. The following equation represents the mass balance approach used:

$$Q_u c_u + Q_e c_e = (Q_u + Q_e) c_d$$

where: Q_u = upstream flow (cfs);
c_u = upstream concentration (mg/L);
Q_e = effluent flow (cfs);
C_e = effluent concentration (mg/L); and
C_d = downstream (mixed) concentration (mg/L).

This equation was solved for c_e to determine the allowable effluent concentration and loading (WLA) given the upstream flow at 7Q2 and background concentration level, effluent design flow and water quality standard (c_d). The NPS LA was determined based on the upstream flow and concentration or, if more than one point source (PS) on a stream reach, as the upstream load plus the incremental load based on the incremental flow between the two locations. If there was a downstream PS, the load from the upstream PS was accounted for in the analysis.

The 7Q2 critical stream flows were determined using the USEPA DFLOW3 stream flow analysis program (http://epa.gov/waterscience/dflow/) and available USGS flow data. The USGS flow data used to calculate 7Q2 low flows were from Rio Bairoa (#50055390, 1990-2000), Rio Caguitas (#50055225, 1990-2003), Rio Gurabo (50057000, 1959-2003) and Rio Grande de Loiza (#50055000, 1959-2003). The DFLOW3 program is a Windows based implementation of the USEPA methodology for stream design flow determination for steady-state modeling as presented in Book VI of the technical guidance manual for performing wasteload allocations (USEPA, 1986). To determine 7Q2 flows at locations other than the flow gages, a drainage area ratio approach was used. For the Rio Bairoa and the Rio Caguitas, the 7Q2 is 2.6 cfs and 6.0 cfs respectively. Analysis of available water quality data with most emphasis put on the recent EPA clean metals data (USEPA, 2005) determined the background copper concentration to be 2.5 ug/l for both Rio Bairoa and Rio Caguitas, which represents the average upstream stream concentrations measured during the 2005 field effort.

Since the Las Carolinas WWTP ceased discharging to Rio Caguitas , the copper standard will be met since the background copper concentration is approximately 2.5 ug/L at 7Q2 low flow conditions. At these conditions the Load Allocation for Rio Caguitas is 0.081 lbs/day..

For the Rio Bairoa, using an upstream 7Q2 low-flow of 2.6 cfs, a background copper concentration of 2.5 ug/L and the Aguas Buenas WWTP flow of 0.6 mgd, the mass balance analysis downstream of the outfall results in a Waste Load Allocation (WLA) for the Aguas Buenas WWTP of 0.069 lbs/day.

4.0 MARGIN OF SAFETY

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002), explains that the MOS may be implicit, i.e., incorporated into the TMDL through conservative assumptions in the analysis, or explicit, i.e., expressed in the TMDL as loadings set aside for the MOS. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS of 10%.

5.0 SEASONAL VARIATIONS/CRITICAL CONDITIONS

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, drought events do occur periodically. While there may be some variability on a year-to-year basis due to weather pattern variability, these TMDLs are based on the 7Q2 critical stream flow for each of the impacted stream segment and hence are protective for all seasons. The 7Q2 critical stream flow is the minimum 7-day average stream flow that occurs once in two years and represents a critical low-flow stream condition used in performing WLAs. In addition, the instream water quality due to the PS loads at flows greater than the 7Q2 will result in compliance with water quality standards due to the increased dilution flow and, therefore, water quality will be protected at higher stream flows.

6.0 PHASE I TMDL ALLOCATION

The Water Quality load calculation approach determined the allowable loads (PS and NPS) that are required to meet the copper standard were based on critical low-flow conditions (7Q2). This analysis identifies a potential WWTP effluent permit limit for Aguas Buenas and Caguas but a more rigorous analysis should be completed before modifying any permit limits.

Table VI-4
COPPER TMDL LOADS

Water body	WLA (lbs/day)	LA (lbs/day)	MOS (lbs/day)	TMDL (lbs/day)
Rio Caguitas	0	0.0729	0.0081	0.081
Rio Bairoa	0.069	0.035	0.0104	0.104

Table VII-5 summarizes the loads and WWTP effluent discharge conditions

Table VI-5

TMDL & LIMITS*

Facility Name	Flow (mgd)	Effluent Concentration (mg/L)	Current Load (lbs/day)	Individual WLA s Copper (lbs/day)
Las Carolinas WWTP	0.22	0.051	0.095	0
Las Carolinas Pump Station	0.0022	0.051	0.0010	0
Aguas Buenas WWTP	0.60	0.051	0.344	0.069
Aguas Buenas Pump Station	0.0080	0.051	0.00344	0
Aguas Buenas WTP	0.081	0.041	0.028	0.010

*Individual WLAs are for the Rio Bairoa
The achievement of the TMDL is addressed in Section 8.

7.0 REASONABLE ASSURANCE

Reasonable assurance for the implementation of this TMDL has been considered for the point and non-point sources of selenium for which management recommendations have been made within this report. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The complex nature of the implementation needs have been recognized throughout development of the Phase I program and have been accommodated through the regular involvement of government agencies in Technical and Executive Steering Committees (USEPA, PREQB, PRDOH, PRASA), as well as the involvement of other agencies at appropriate times (USDA, PRDNR, UPR). A Stakeholder Involvement Program has also been initiated to include municipal government, industry groups, public organizations, including environmental groups and local citizenry, and commerce.

It is the expectation that these efforts will produce the governmental, as well as public and industry support necessary to accomplish the implementation of the activities which have been specified as required to fulfill the Phase I TMDL. It is anticipated that this support will need to include information, education effort, financial and other incentives, and regulatory follow-up.

8.0 IMPLEMENTATION

A review of all point and non-point sources of copper to these segments has resulted in the identification of the following options for reducing copper inputs.

8.1 Water/Wastewater Treatment Plant Conditions/Operation

Sampling conducted by EPA using clean techniques and lower detection level analyses indicated that both the Aguas Buenas and Caguas WWTPs were not violating the copper discharge limit and the water quality criterion for the Rio Bairoa was not violated. An intensive sampling program performed monthly over a 1-year period using the clean technologies and low level detection analyses should be performed at the Aguas Buenas WTP, Aguas Buenas WWTP and instream to determine whether the copper water quality standard is being met. If the water quality standard is not being achieved, a copper trackdown program should be implemented to determine the copper sources.

8.2 Septic Tank Management

Although a need for reduction in this source has not been identified in the LA, it is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows onto ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), a reduction in copper reaching the surface waters can be achieved.

In the immediate future, septic system owners should be educated on the proper use and maintenance of a septic system.

8.3 Sewage Pumping Station Bypass and Collection System Overflow Elimination

An asset management program such as EPA's Voluntary Capacity Management Operation and Maintenance (CMOM) program aimed at eliminating the loadings from sewage pumping stations and collection system is needed to achieve water quality standards.

8.4 Municipal Storm Water Management

Although a need for reduction in this source has not identified in the LA, the municipalities should implement the Best Management Practices (BMP) as proposed in EPA's Draft General Permit to further reduce the nonpoint source load.

9.0 FOLLOW-UP MONITORING

A phased approach to implementation is appropriate for the copper TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the PREQB and the USGS at the water quality monitoring stations identified above on a quarterly basis. These efforts will continue to track water quality improvements and to assure that the copper water quality standard is achieved.

10.0 STAKEHOLDER INVOLVEMENT/PUBLIC PARTICIPATION

A Stakeholder Involvement Program aimed at involving all elements of the public (municipal government, industry, commerce, public, organizations, general, public, etc.) within the watershed has been ongoing. The goal is to assure the participation of all those that will be affected in the development of the goals and objectives, as well as the implementation of the recommendations of the study. A further goal is the establishment of a structure and membership which will serve the ongoing need for a watershed steward group, assuring a continued focus on improving water quality through the implementation of the recommendations of this study, as well as of those which may be developed in the future.

VII. RIO GRANDE DE LOIZA WATERSHED DISSOLVED OXYGEN TMDLs

1.0 IDENTIFICATION OF ASSESSMENT UNIT/ POLLUTANT OF CONCERN/ PRIORITY RANKING

The assessment units are the Rio Caguitas (PRER0110b_00), Rio Bairoa (PRER0109b_00), Rio Gurabo (PRER0108b_00) and the Quebrada Sin Nombre (tributary to the Rio Grande de Loiza (PRER0110h_02). The length of the Rio Caguitas, Rio Bairoa and the Rio Gurabo are 16.2, 7.3 and 18.6 miles, respectively. The stream length of the Quebrada Sin Nombre is currently unknown. The pollutant of concern is dissolved oxygen as potentially affected by BOD oxidation and ammonia nitrification. The impaired waters listing for each specifies the water quality problem as having a high priority. These impaired waters are classified as Class SD. The water quality standard for dissolved oxygen in these surface waters, as stated in Section 3.2.4(B)(1) of the Puerto Rico Water Quality Standards Regulation (PRWQSR), As Amended, on March 2003 is:

> *"Dissolved Oxygen: Shall contain not less than 5.0 mg/l except when natural conditions cause this value to be depressed."*

The designated use that has been established by the Environmental Quality Board for Class SD water in Section 3.2.4 (A) of the PRWQSR is stated below:

> *"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. Primary contact recreation is precluded in any stream or segment that does not comply with Section 3.2.4(B)12 of this article until such stream or segment meets the goal of the referred section."*

2.0 POLLUTANT SOURCES AND ASSESSMENTS

Source assessments are warranted in order to evaluate and characterize dissolved oxygen loadings to the Rio Bairoa, Rio Caguitas, Rio Gurabo and Quebrada Sin Nombre, and propose proper management responses. Source assessments include evaluation of all significant point sources and their relative contributions to the dissolved oxygen loadings, as well as calculation of total nonpoint source loadings. To determine the allowable loadings to these streams, a DO analysis framework based on WLA Guidelines dated August 1995, submitted to the Puerto Rico Environmental Quality Board in conjunction with a Streeter-Phelps DO deficit model, was used.

2.1 Assessment of Point Sources other than Storm Water

The major point sources on these streams are Las Carolinas WWTP (Rio Caguitas), Aguas Buenas WWTP (Rio Bairoa) and Juncos WWTP (Rio Gurabo), as well as attendant wastewater pumping stations. There are no WWTPs on Quebrada Sin Nombre, but there is one wastewater pumping station. Also, there are three Water Treatment Plants (WTP) located upstream of or on these streams. These facilities are the Aguas Buenas WTP (Rio Bairoa), Gurabo WTP (Rio Gurabo) and Ceiba Sur WTP (Rio Gurabo). The NPDES effluent permit limits, permit number, location and receiving water are presented in Table VII-1.

Table VI1-1
NPDES PERMIT LIMITS

Facility Name	NPDES #	Map ID Number	Flow (mgd)	BOD_5 (mg/l)	NH_3 (mg/l)	Receiving Water
Aguas Buenas WWTP	PR0024732	P1	0.60	30	10	Rio Bairoa
Juncos WWTP	PR0020567	P3	1.2	30	2.1	Rio Valenciano
Aguas Buenas WTP	PR0022896	PR1	0.081	30	1	Morena Creek
Gurabo WTP	Not Available	NF2	Not Available	Not Available	Not Available	Rio Gurabo
Ceiba Sur WTP	PR0025119	PR4	0.10	10	No limit	Rio Valenciano
Las Carolinas WWTP	PR0024731	Ceased Discharging (8/2005)	0.22	30	20	Rio Caguitas
Limit Type			Daily Max	Monthly Average	Daily Max	

The available WWTP effluent data (flow, BOD_5, NH_3) for the Las Carolinas, Aguas Buenas and Juncos WWTPs during 2002 to 2005 are presented in Figures VII-1 through VII-3. The Las Carolinas WWTP ceased discharging in August 2005 and the wastewater is currently pumped to the Caguas WWTP. The effluent data show occasional with BOD_5 levels greater than

30 mg/l and NH_3 levels greater 10 mg/l. Average values are reported in Table VIII-2 (excludes upsets).

Table VII -2
AVERAGE WWTP EFFLUENT CHARACTERISTICS (2002-2005)

WWTP	NPDES #	Flow (mgd)	BOD_5 (mg/l)	NH_3 (mg/l)
Las Carolinas	PR0020273	0.32	19	11
Aguas Buenas	PR0024732	0.36	5	0.3
Juncos	PR0020567	1.43	11	5.9

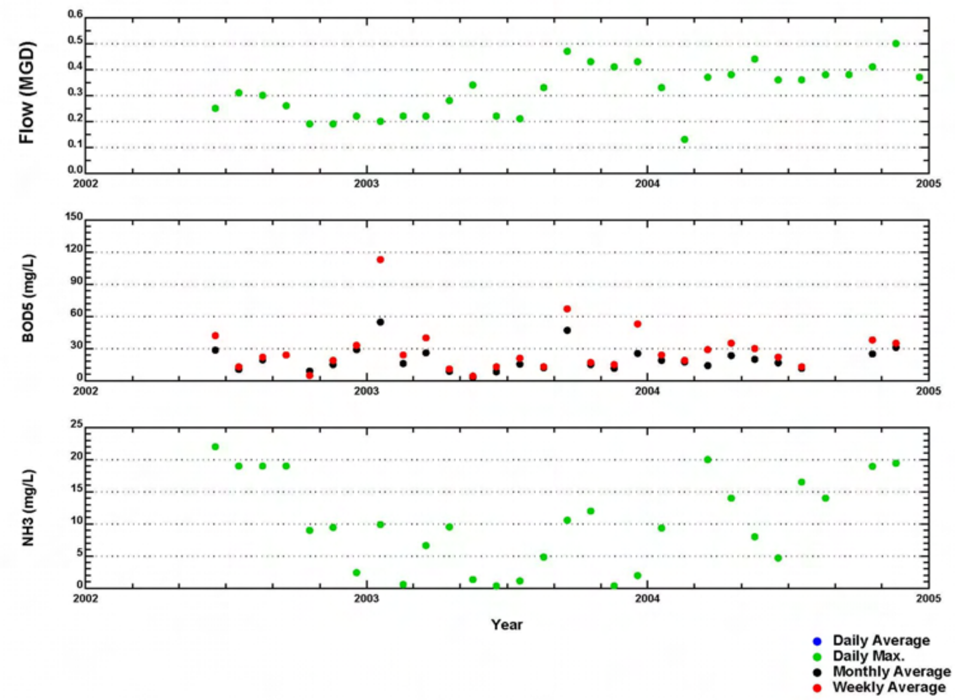
The 2004 water treatment plant effluent data (flow, BOD_5, NH_3) for the Aguas Buenas and Ceiba Sur WTPs are presented in Table VIII-3. The Gurabo WTP is currently operating but effluent data is not available. Typically, the Aguas Buenas and Ceiba Sur WTP discharges are well below the permitted limit. Biochemical oxygen demand loadings from these facilities (less than 5 lbs/day) are not significant when compared to other sources.

Table VII -3
AVERAGE WTP EFFLUENT CHARACTERISTICS (2004)

WTP	NPDES #	Flow (mgd)	BOD_5 (mg/l)	NH_3 (mg/l)
Aguas Buenas	PR0022896	0.04	1.88	0.56
Ceibur Sur	PR0025119	0.059	3.72	No data

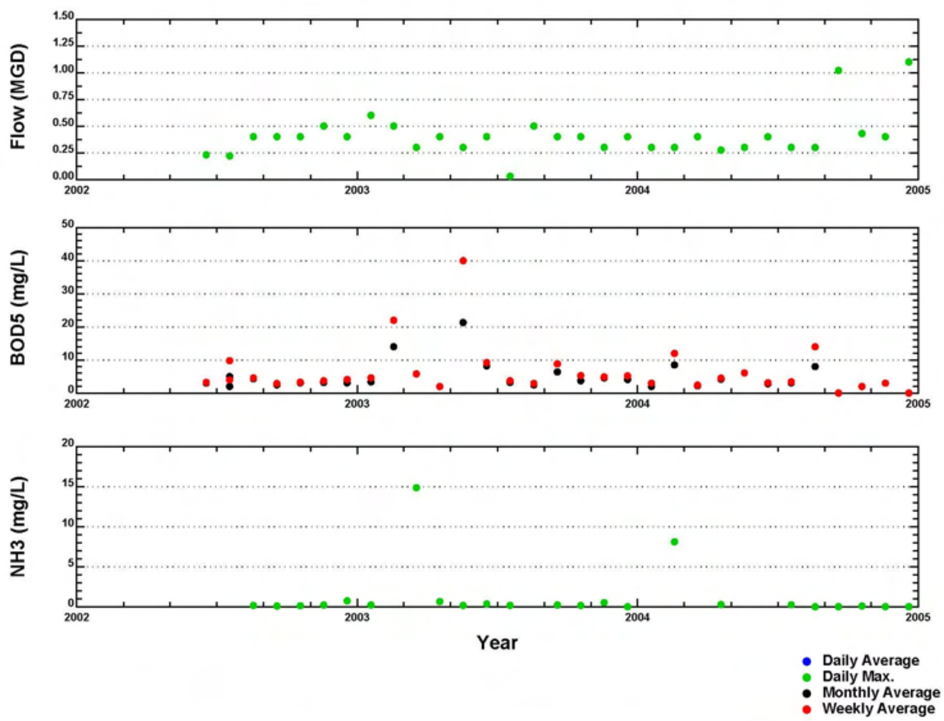
The pump station bypass load of BOD_5 and NH_3 is estimated to be 1% of the WWTP flow and the WWTP permit limit ([lbs/day] = 0.01 x flow [mgd] x 8.34 x concentration [mg/L]). Because pump station bypass is illegal and will be address through NPDES compliance enforcement, the TMDL load for pump station bypass of BOD_5 and NH_3 equals 0.0 ug/L.

Figure VII-1



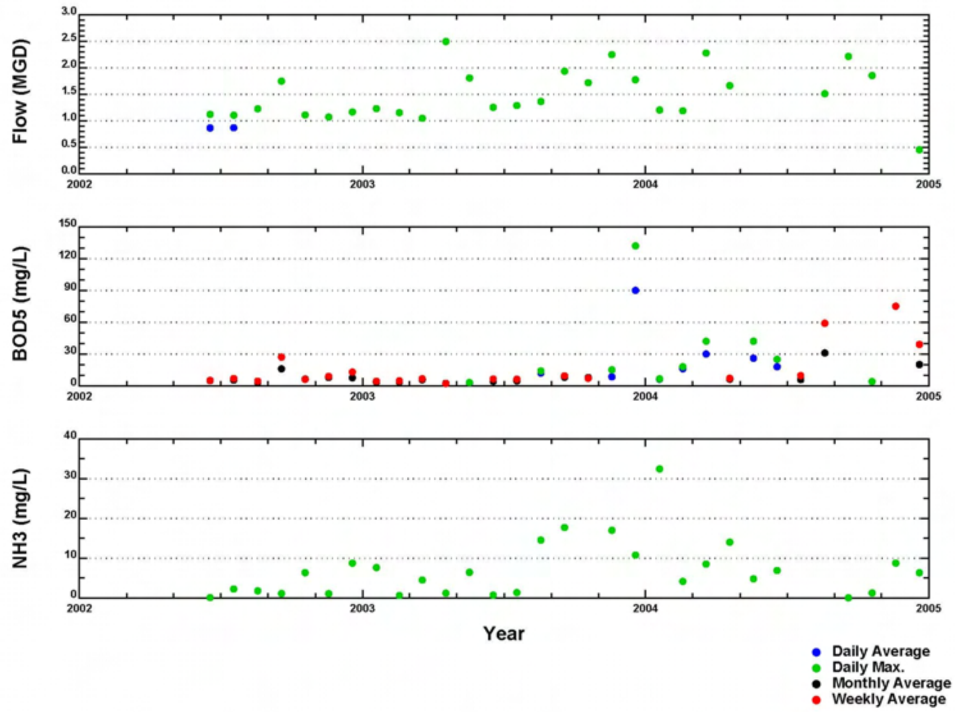
DMR Data (2002-2004) - Las Carolinas WWTP, Loiza Watershed

Figure VII-2



DMR Data (2002-2004) - Aguas Buenas WWTP, Loiza Watershed

Figure VII-3



DMR Data (2002-2004) - Juncos WWTP, Loiza Watershed

2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Nonpoint sources include animal feeding operations and grazing, septic system failures, urban runoff and, for this analysis, wastewater pumping station failures and sewer system overflows.

As discussed in Section IV, The Rio Grande de Loiza watershed was delineated into 15 subwatersheds (see Figure IV-1). The four streams being analyzed here are located within LSPC Segments 4 (Rio Gurabo), 5 (Rio Bairoa), 7 (Rio Caguitas) and 12 (Quebrada Sin Nombre). It should be noted that each subwatershed area is greater than the drainage area of the listed assessment unit. The LSPC subwatersheds were only utilized to identify potential sources within the drainage areas that could have an impact on water quality.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. The animal feeding operations located in the LSPC segments are summarized in Table VIII-4 and are identified in Table B-3.

Table VII-4
ANIMAL FEEDING OPERATIONS

LSPC Segment	Stream	Dairy	Horse	Poultry	Swine	Beef
4	Rio Gurabo	3	7	0	2	1
5	Rio Bairoa	0	0	0	0	0
7	Rio Caguitas	0	2	1	0	0
12	Quebrada Sin Nombre	1	0	2	4	0

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined.

Table VII-5
SEWERED/UNSEWERED POPULATION

LSPC Segment	Total Population	Sewered Population	Unsewered Population	% Unsewered
4	32,872	10,740	22,132	67
5	13,793	11,591	2,202	16
7	67,662	44,516	23,146	34
12	38,009	11,182	26,827	71

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program. Therefore all urban runoff is considered a nonpoint source.

3.0 WATER QUALITY ANALYSIS

As described in EPA Guidance, a TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards (40 CFR 130.2). The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). For dissolved oxygen TMDL, it is appropriate to express the TMDL on a daily basis. Daily pollutant loadings are more critical to river dissolved oxygen during low flow conditions, especially during the 7Q2 critical stream flow.

3.1 Surface Water Quality Data Overview

The United States Geological Service (USGS) maintains Water Quality Stations 50055250 (Station 2 on Figure IV-1, Rio Caguitas at HWY 30 at Caguas), 50055400 (Station 3 on Figure IV-1, Rio Bairoa near Caguas) and 50057025 (Station 4 on Figure IV-1, Rio Gurabo near Gurabo). The Puerto Rico Environmental Quality Board (PREQB) maintains the Water Quality Gage L-2 (Station 3 on Figure IV-1, Rio Grande de Loiza (Quebrada Sin Nombre) near San Lorenzo). The DO data for these four streams are presented in Figures VII-4 through VII-7. These figures include data for water temperature, DO and DO saturation (DOsat) as a function of temperature and elevation, and DO deficit (DOsat–DO) at the USGS stations and the EQB station. Data prior to 1999/2000 were not used to represent water quality in these streams because of upstream WWTP upgrades (based on reduced instream COD data). The data from 1999/2000 forward indicate occasional DO violations (less than the 5 mg/l standard) in Rio Caguitas, one excursion period in 2003 for Rio Bairoa, and frequent violations in Rio Gurabo and Quebrada Sin Nombre. These DO violations are most likely due to upstream point sources (WWTPs and wastewater pumping station failures) and nonpoint sources (failing septic systems, and animal grazing and feeding operations).

3.2 Water Quality Model, Calibration and Load Calculation

To determine the allowable loadings to these streams, a DO analysis framework based on Wasteload Allocation (WLA) Guidelines, dated August 1995, submitted to the Puerto Rico Environmetal Quality Board in conjunction with a Streeter-Phelps DO deficit model, were used. This approach requires information about stream geometry (depth, width, velocity, slope), stream flow and temperature, atmospheric reaeration (Ka), BOD oxidation (Kd), sediment oxygen demand (SOD), point and nonpoint sources of BOD_5 and NH_3.

Stream depth and width was based on information contained in the 1995 WLA guidelines (Figure E-1) with velocity calculated from the cross-sectional area and flow. Slight modifications to the stream width and depth were made based on available stream information. Stream slopes were estimated from USGS topographic maps and slightly modified in areas

Figure VII-4

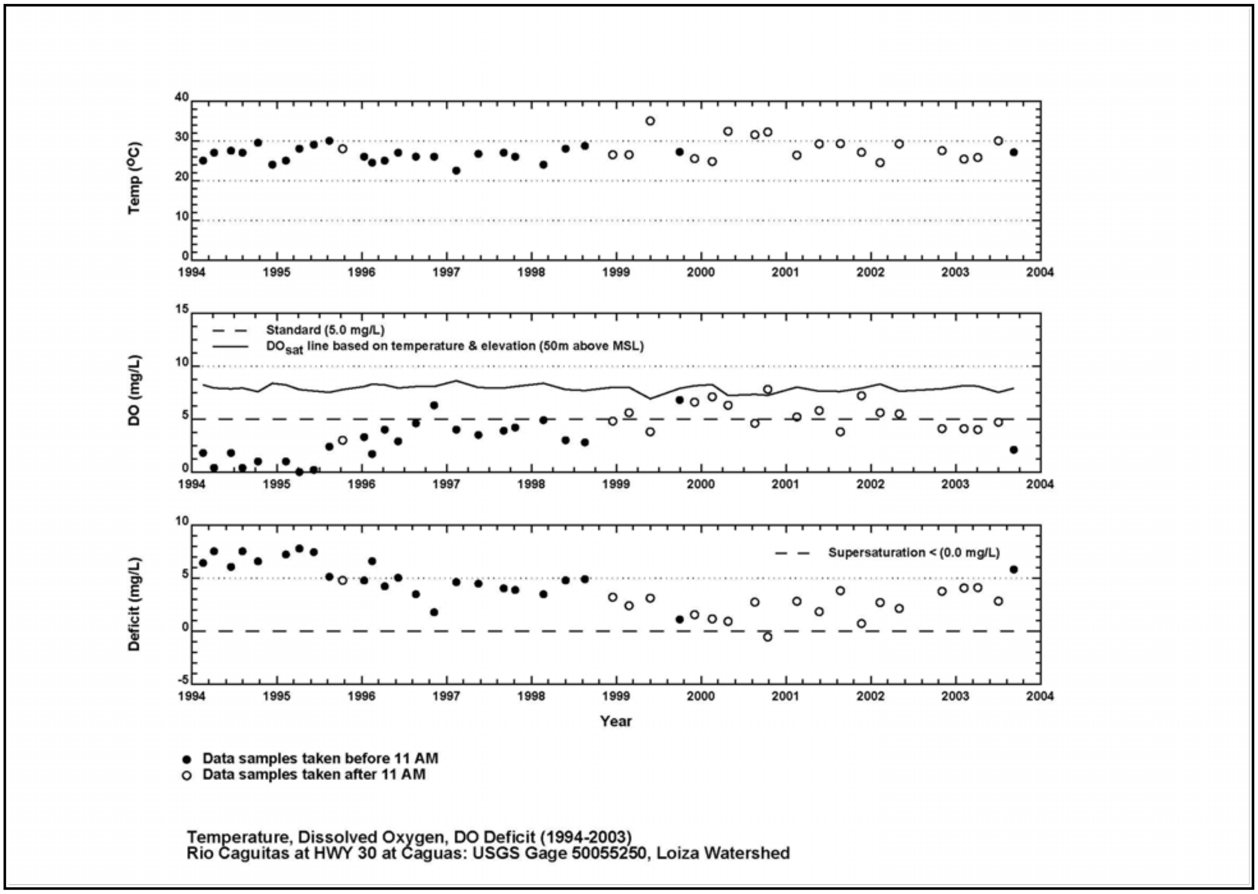
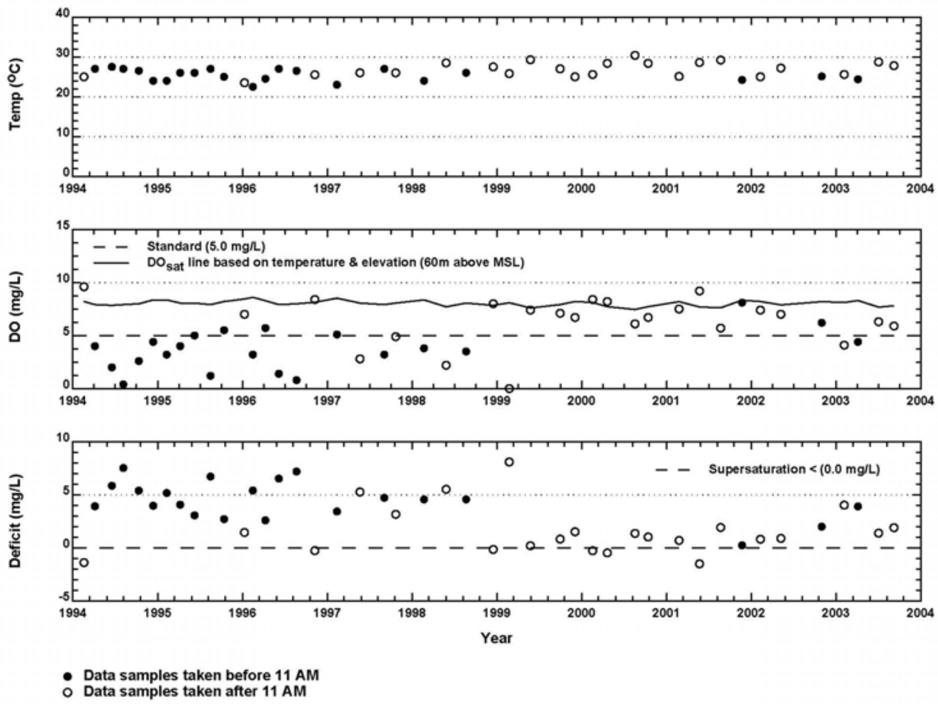

Temp (°C)
DO (mg/L)
Standard (5.0 mg/L)
DOsat line based on temperature & elevation (50m above MSL)
Deficit (mg/L)
Supersaturation < (0.0 mg/L)
Year
Data samples taken before 11 AM
Data samples taken after 11 AM
Temperature, Dissolved Oxygen, DO Deficit (1994-2003)
Rio Caguitas at HWY 30 at Caguas: USGS Gage 50055250, Loiza Watershed

Figure VII-5



Temperature, Dissolved Oxygen, DO Deficit (1994-2003)
Rio Bairoa near Caguas: USGS Gage 50055400, Loiza Watershed

Figure VII-6

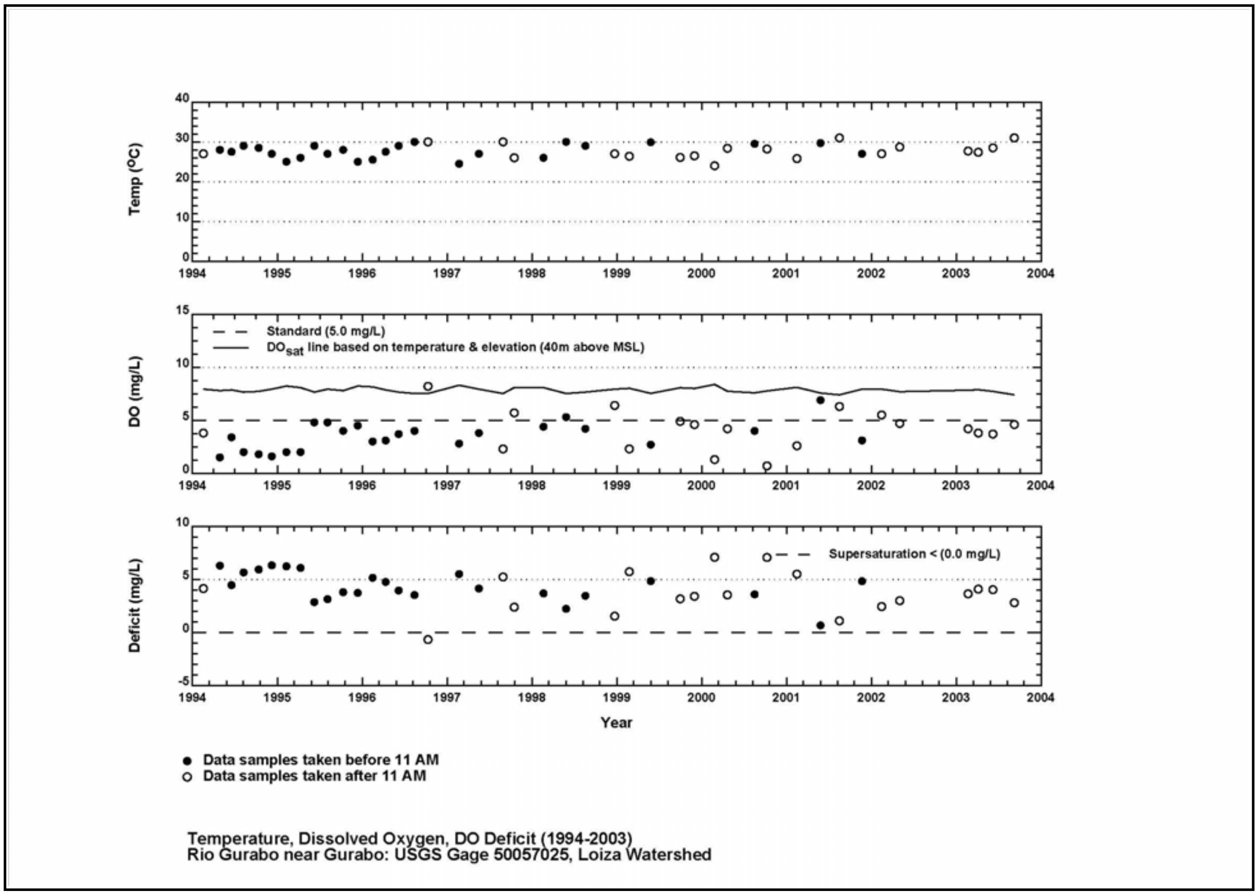
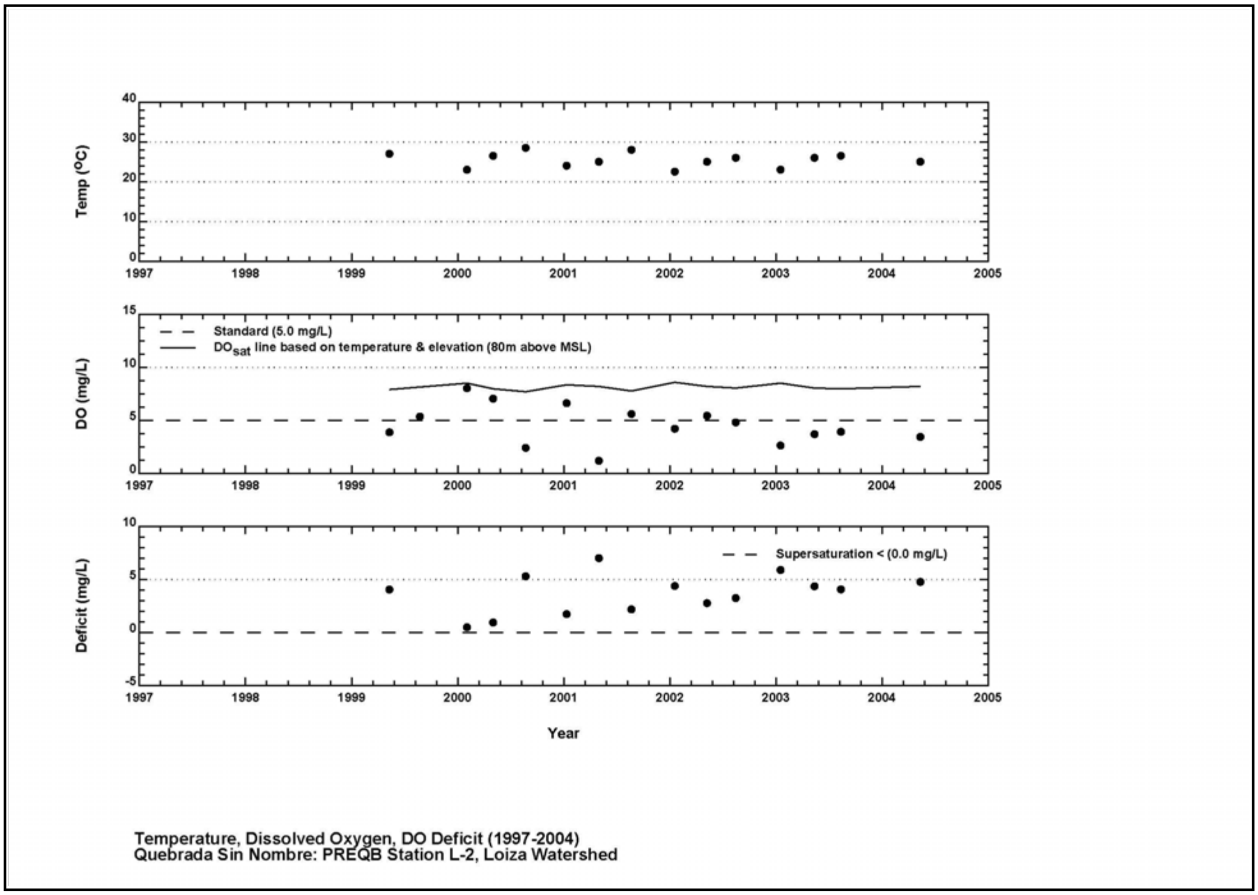

Temp (ºC)
DO (mg/L)
Deficit (mg/L)
Year
Standard (5.0 mg/L)
DOsat line based on temperature & elevation (40m above MSL)
Supersaturation < (0.0 mg/L)
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
Data samples taken before 11 AM
Data samples taken after 11 AM
Temperature, Dissolved Oxygen, DO Deficit (1994-2003)
Rio Gurabo near Gurabo: USGS Gage 50057025, Loiza Watershed

Figure VII-7


Temp (°C)
40
30
20
10
0
1997
1998
1999
2000
2001
2002
2003
2004
2005
15
10
5
0
Standard (5.0 mg/L)
DOsat line based on temperature & elevation (80m above MSL)
DO (mg/L)
Deficit (mg/L)
Supersaturation < (0.0 mg/L)
-5
Year
Temperature, Dissolved Oxygen, DO Deficit (1997-2004)
Quebrada Sin Nombre: PREQB Station L-2, Loiza Watershed

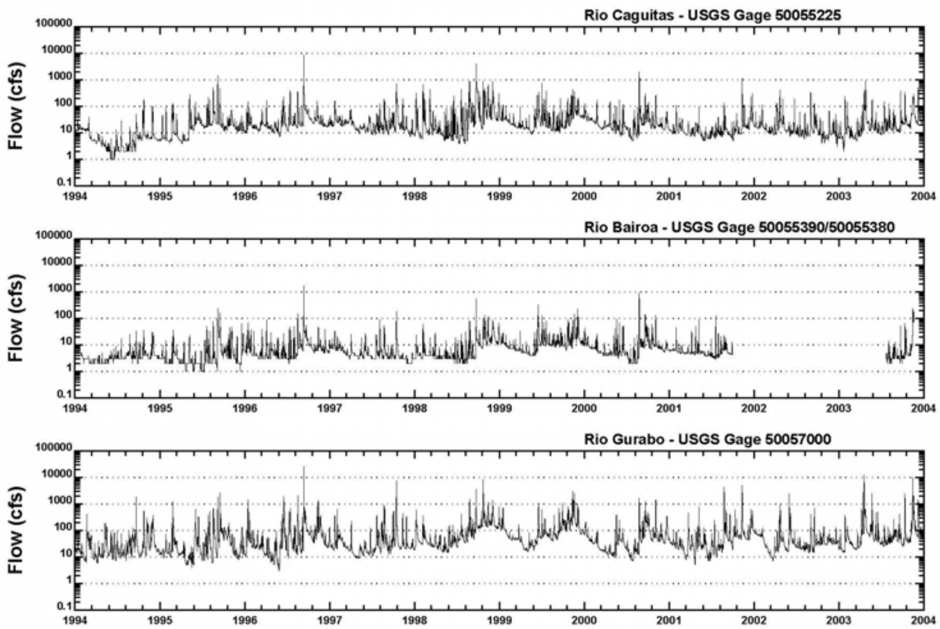
where lake backwater effects or limited topographic information was available. Atmospheric reaeration was calculated using the Tsivoglou reaeration equation (Ka = 1.8US, where U is velocity in fps and S is slope in ft/mile). A BOD oxidation rate of 0.5/day was used based on reproducing the observed DO data and as guided by Figure E-3 from the WLA guidelines. A nominal background SOD of 1 g/m^2/day was also used in the analysis. An upstream and incremental flow NH_3 level of 0.2 mg/l was used for Rio Caguitas, Rio Bairoa and Rio Gurabo. An upstream and incremental flow BOD_5 of 30 mg/l on Rio Caguitas, 40 mg/l on Rio Bairoa and 10 mg/l on Rio Gurabo was used to represent background BOD sources due to potential pumping station failures and urban loads. For Quebrada Sin Nombre, values of 20 mg/l BOD_5 and 2 mg/l NH_3 were used to represent background BOD sources due to potential pumping station and septic system failures. A stream temperature of 30°C was used to represent summer low-flow conditions and to correct the rates (Ka, Kd, SOD) to 30°C from 20°C. The 7Q2 critical stream flows were determined using the USEPA DFLOW3 stream flow analysis program (http://epa.gov/waterscience/dflow/) and available USGS flow data. The USGS flow data used to calculate 7Q2 low flows were from Rio Bairoa (#50055390, 1990-2000), Rio Caguitas (#50055225, 1990-2003), Rio Gurabo (50057000, 1959-2003) and Rio Grande de Loiza (#50055000, 1959-2003). The DFLOW3 program is a Windows based implementation of the USEPA methodology for stream design flow determination for steady-state modeling as presented in Book VI of the technical guidance manual for performing wasteload allocations (USEPA, 1986). To determine 7Q2 flows at locations other than the flow gages, a drainage area ratio approach was used. The stream length used in the analyses is the distance from the WWTP to the nearest downstream water quality monitoring station. A summary of this information is presented in Table VIII -6

Table VII-6
STREAM CHARACTERISTICS

Water Body	7Q2 (cfs)	Length (mi)	Slope (ft/mi)	Velocity (fps)	Depth (ft)	Width (ft)	Travel Time (days)	Ka (1/day)
Rio Caguitas	6.0	6.3	15-30	0.4	0.7	18	1.1	12-24
Rio Bairoa	2.6	6.5	30-150	0.4	0.5	7.6	1.1	26-122
Rio Gurabo	14.0	7.2	5-7	0.2	1.1	54	2.0	2.5-3.4
Quebrada Sin Nombre	1.8	1.0	15	0.4	0.6	9.4	0.2	13

Since the low DO levels in these streams were typically observed in early 2003 for an extended period of time (3 months), this period was used to test the information assembled to complete the DO analysis. Stream flows in these streams are presented in Figure VII-8 and during this 3-month period the flows were close to the 7Q2 critical flow conditions. Point source

Figure VII-8



USGS Flows in the Rio Grande de Loiza Watershed (1994-2003) loading information (WWTP) was compiled for this period and combined with estimates of stream flow to develop upstream and incremental NPS loads. The NPS LA was determined based on the upstream flow and concentration or, if more than one Point Source (PS) was present on a stream reach, as the upstream load plus the incremental load based on the incremental flow between the two locations. If there was a downstream PS, the load from the upstream PS was accounted for in the analysis. The loads used for the low DO analysis (MA7Q2) are presented in Table VII-7 along with the critical DO deficit and DO in Table VII-8. In general, the analysis shows that given the available stream and load information that the low observed DO levels in 2003 (~3-4 mg/l) are reproduced by the DO analysis approach as summarized below.

Table VII-7
LOW DO EFFLUENT CONDITIONS

WWTP	Flow (mgd)	BOD_5 (mg/l)	NH_3 (mg/l)	TBODu (mg/l)
Las Carolinas	0.20	30	10	136
Aguas Buenas	0.60	20	15	129
Juncos	1.20	10	5	53

Table VII-8
WATER BODY LOW DO CONDITIONS

Water Body	NPS TBODu (lb/d)	PS TBODu (lb/d)	Total DO Deficit (mg/l)	Critical DO (mg/l)
Rio Caguitas	4092	226	4.0	3.5
Rio Bairoa	2151	643	3.5	4.0
Rio Gurabo	2499	529	4.2	3.3
Quebrada Sin Nombre	745	0	3.5	4.0

- On the Rio Caguitas, the DO approach generally reproduced the low levels observed in 2003 given the point and nonpoint source loads assigned. During the analysis period, the Las Carolinas WWTP was discharging to Rio Caguitas, but the discharge has since been discontinued with the wastewater pumped to the Caguas WWTP.

- On the Rio Bairoa, the low DO levels were only observed in the 2003 period and seem to be a combination of low flow and higher than usual loadings from the Aguas Buenas WWTP coupled with NPS loadings. DO levels in Rio Bairoa are typically greater than the standard of 5 mg/l and typical operation of the Aguas Buenas WWTP does not seem to impact DO levels at other conditions. Assigning the higher WWTP loads along with the nonpoint source loads generally reproduced the low DO levels in 2003.

- On the Rio Gurabo, there are more frequent violations of the DO standard, which may be due to both the Juncos WWTP and pump station failures. During the period of 2003-2005, there were 129 total bypasses (pump station and sewer system), with 79 events lasting more than 1 day, for a total of 713 days of overflows. Of these events, 80% were directly into a water body that enters Rio Gurabo upstream of the listed segment and could also contribute to the low observed DO levels downstream. Assignment of the WWTP loads along with the nonpoint source loads generally reproduced the low DO levels.

- On the Quebrada Sin Nombre, there are no WWTP discharges, but there is one pumping station and septic systems upstream from the location of measured low DO levels. These sources can potentially cause the DO violations through failures or continuous loads and were adjusted to reproduce the low DO levels.

4.0 MARGIN OF SAFETY

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002)), explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis), or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS of 10%.

5.0 SEASONAL VARIATIONS/CRITICAL CONDITIONS

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, drought events do occur periodically. While there may be some variability on a year-to-year basis due to weather pattern variability, these TMDLs are based on the 7Q2 critical stream flow for each of the impacted stream segment and, hence, are protective for all seasons. The 7Q2 critical stream flow is the minimum 7-day average stream flow that occurs once in two years and represents a critical low-flow stream condition used in performing WLAs. In addition, the instream water quality due to the PS loads at flows greater than the 7Q2 will result in compliance with water quality standards due to the increased dilution flow and, therefore, water quality will be protected at higher stream flows.

6.0 PHASE I TMDL ALLOCATION

Since the Water Quality modeling approach generally reproduced the low observed DO levels in the four water bodies, the approach was used to determine the allowable loads (PS and NPS) that are required to meet the DO standard of 5 mg/l at summer, critical low-flow conditions (7Q2). This analysis identifies potential WWTP effluent permit limits, but a more rigorous analysis should be completed before modifying any permit limits. The additional work should include field surveys to better define the inputs (stream geometry, travel time, loads) and additional modeling of the streams, and has been include as part of the proposed Phase II program.

Table VII-9 presents the TMDL loading conditions for both point and nonpoint sources that will meet the DO standard of 5 mg/l at summer (30°C), low-flow (7Q2) stream conditions.

Table VII-9
TMDL LOADING CONDITIONS

Water Body	NPS TBODu (lb/d)	PS TBODu (lb/d)	Total DO Deficit (mg/l)	Critical DO (mg/l)
Rio Caguitas	319	0	0.5	7.0
Rio Bairoa	137	679	1.4	6.1
Rio Gurabo	748	771	2.5	5.0
Quebrada Sin Nombre	107	0	0.6	6.9

The following TMDL results are noted for the four streams.

- In Rio Caguitas, removal of the Las Carolinas WWTP discharge and assigning a background BOD_5 concentration of 3 mg/l (i.e., no pump station failures) resulted in calculated DO levels greater than the standard (~7 mg/l).

- In Rio Bairoa, the WWTP discharge from Aguas Buenas was assigned at their BOD_5 and NH_3 effluent permit limits of 30 mg/l and 10 mg/l, respectively. In addition, a background BOD_5 concentration of 3 mg/l was assigned (i.e., nonpump station failures). The resulting calculated DO levels are greater than the standard (~6 mg/l).

- In Rio Gurabo, the WWTP discharge from Juncos was assigned a reduced BOD_5 effluent limit of 15 mg/l and an increased NH_3 effluent limit of 7 mg/l from their current permit. In addition, a background BOD_5 concentration of 3 mg/l was assigned (assumes pump station failures are eliminated). For the Juncos WWTP, the BOD_5 and NH_3 effluent limits used may require better operation or upgrade of the WWTP since the plant appears to be at or above design conditions based on effluent flow records and the increasing effluent quality. The resulting calculated DO levels are equal to the standard (~5 mg/l).

- In Quebrada Sin Nombre, the background BOD_5 and NH_3 concentrations were reduced to background levels of 3 mg/l and 0.2 mg/l, respectively, to represent elimination of pump station and septic system failures. The resulting calculated DO levels are greater than the standard (~7 mg/l).

The TMDL for TBODu (total oxygen demand from BOD_5 and NH_3) loads are presented in Table VII-10 for both point and nonpoint sources by water body.

Table VII-10
TBODu TMDL

Water Body	WLA (lbs/day)	LA (lbs/day)	MOS (lb/day)	TMDL (lbs/day)
Rio Caguitas	0	287.1	31.9	319
Rio Bairoa	679 (Aguas Buenas WWTP)	55.4	81.6	816
Rio Gurabo	771 (Juncos WWTP)	596.1	151.9	1519
Quebrada Sin Nombre	0	96.3	10.7	107

Table VIII-11 summarizes the loads and WWTP effluent discharge conditions

Table VII-11
WWTP EFFLUENT LIMITS

WWTP	Flow (mgd)	BOD_5 (mg/l)	NH_3 (mg/l)	TBODu (mg/l)
Las Carolinas	0.00	0	0	0
Aguas Buenas	0.60	30	10	136
Juncos	1.20	15	7	77

The DO calculations and Phase I TMDLs should be revisited with better information and refined modeling completed to better estimate the DO impacts in the receiving streams. The additional information should include better definition of stream geometry, travel time and, most importantly, the loads from pumping station/septic system failures and WWTPs. The steep, fast moving streams in the watershed provide ideal conditions for increased assimilation capacity, but the additional information will help to better understand the loading and receiving stream impacts associated with both point and nonpoint sources.

7.0 REASONABLE ASSURANCE

Reasonable assurance for the implementation of this TMDL has been considered for the dissolved oxygen point and nonpoint sources for which management recommendations have been made within this report. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The complex nature of the implementation needs have been recognized throughout development of the Phase I program and have been accommodated through the regular involvement of government agencies in Technical and Executive Steering Committees (USEPA, PREQB, PRDOH, PRASA), as well as the involvement of other agencies at appropriate times (USDA, PRDNR, UPR). A Stakeholder Involvement Program has also been initiated to include municipal government, industry groups, public organizations, including environmental groups and local citizenry, and commerce.

It is the expectation that these efforts will produce the governmental as well as public and industry support necessary to accomplish the implementation of the activities which have been specified as required to fulfill the Phase I TMDL. It is anticipated that this support will need to include information, education effort, financial and other incentives, and regulatory follow-up.

8.0 IMPLEMENTATION

A review of all point and nonpoint sources of BOD_5 and NH_3 input to Río Grande de Loíza has resulted in the identification of the following options for reducing BOD_5 and NH_3 inputs:

8.1 Pasture (Animal Feeding Operation/Grazing Controls)

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of biochemical oxygen demanding substances into the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; filtered and improved manure management practices to ensure proper placement and stabilization.

Studies* have shown implementation of these recommendations could reduce the nitrogen load from these sources by 60%.

---

*USEPA, Polluted Runoff, Management Measures Guidance

8.2 Septic Tank Management

Although a need for reduction in this source has not been identified in the LA, it is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number but a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.) These failures result in overflows onto ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), a reduction in BOD_5 and NH_3 reaching the surface waters can be achieved.

In the immediate future, septic system owners should be educated on the proper use and maintenance of a septic system.

8.3 Sewage Pumping Station Bypass and Collection System Overflow Elimination

An asset management program such as EPA's Voluntary Capacity Management Operation and Maintenance (CMOM) program aimed at eliminating the loadings from sewage pumping stations and collection system is needed to achieve water quality standards.

8.4 Municipal Storm Water Management

The municipalities should implement the Best Management Practices (BMP) as proposed in EPA's Draft General Permit to further reduce the nonpoint source load.

9.0 FOLLOW-UP MONITORING

The Phase I TMDL presented in the preceding is acknowledged as being based on limited data, as was reasonably available from existing sources. To estimate the DO impacts in the receiving streams, the stream geometry, travel time, atmospheric reaeration, sediment oxygen demand, etc were developed using guidelines. The steep, fast-moving streams in the watershed provide ideal conditions for increased assimilation capacity and the additional information will help to better understand the loading and receiving stream impacts associated with both point and nonpoint sources. The point and nonpoint source loadings are also acknowledged as complex in nature and required significant simplifying assumptions.

A phased approach to implementation is appropriate for dissolved oxygen TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the PREQB and the USGS at the water quality monitoring stations identified above on a quarterly basis. These efforts will continue to track water quality improvements and to assure that the dissolved oxygen water quality standard is achieved.

10.0 STAKEHOLDER INVOLVEMENT/PUBLIC PARTICIPATION

A Stakeholder Involvement Program aimed at involving all elements of the public (municipal government, industry, commerce, public, organizations, general, public, etc.) within the watershed has been ongoing. The goal is to assure the participation of all those that will be affected in the development of the goals and objectives, as well as the implementation of the recommendations of the study. A further goal is the establishment of a structure and membership which will serve the ongoing need for a watershed steward group, assuring a continued focus on improving water quality through the implementation of the recommendations of this study, as well as of those which may be developed in the future.

VIII. RIO GRANDE DE LOIZA WATERSHED AMMONIA TMDLs

1.0 IDENTIFICATION OF ASSESSMENT UNIT/POLLUTANT OF CONCERN/ PRIORITY RANKING

The assessment units are the Rio Caguitas (PRER0110b_00) and Rio Bairoa (PRER0109b_00). The length of the Rio Caguitas and Rio Bairoa are 16.2 and 7.3 miles, respectively. The pollutant of concern is total ammonia. The impaired waters listing for each specifies the water quality problem as having a high priority. These impaired waters are classified as Class SD. The water quality standard for total ammonia in these surface waters, as stated in Section 3.2.4(B)(1) of the Puerto Rico Water Quality Standards Regulation (PRWQSR), As Amended, on March 2003 is:

> *Total Ammonia: Shall not exceed 1.0 mg/l upstream from the points given by the coordinates for the following segments:*
> *Rio Caguitas - 18E15'28" / 66E01'26"*
> *Rio Bairoa - 18E15'28" /66E02'13"*

The designated use that has been established by the Environmental Quality Board for Class SD water in Section 3.2.4 (A) of the PRWQSR is stated below.

> "*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. Primary contact recreation is precluded in any stream or segment that does not comply with Section 3.2.4(B)12 of this article until such stream or segment meets the goal of the referred section.*"

2.0 POLLUTANT SOURCES AND ASSESSMENTS

Source assessments are warranted in order to evaluate and characterize ammonia loadings to the Rio Bairoa and Rio Caguitas and propose proper management responses. Source assessments include evaluation of all significant point sources and their relative contributions to the total ammonia loadings and calculation of total nonpoint source loadings.

2.1 Assessment of Point Sources other than Storm Water

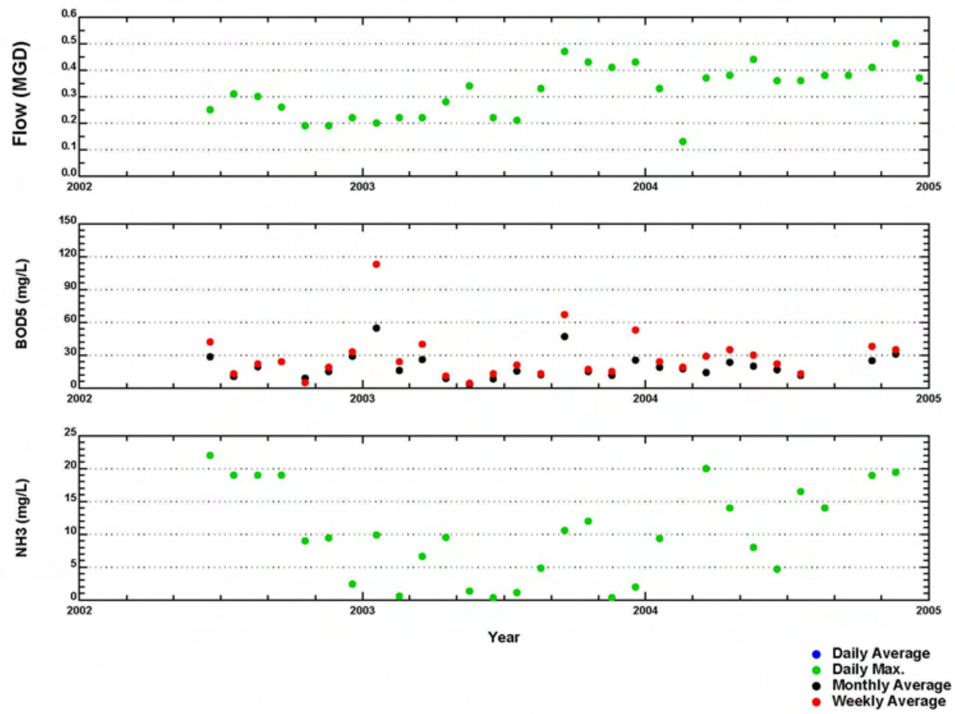
The major point sources of ammonia on these streams were the Las Carolinas WWTP (Rio Caguitas) and the Aguas Buenas WWTP (Rio Bairoa), as well as attendant wastewater pumping stations. The Aguas Buenas Water Treatment Plant (WTP) is located on a creek upstream of the Rio Bairoa. The NPDES effluent permit limits, permit number, location and receiving water are presented in Table VIII-1.

Table VIII-1
NPDES PERMIT LIMITS

Facility Name	NPDES #	Map ID Number	Flow (mgd)	NH_3 (mg/l)	Receiving Water
Aguas Buenas WWTP	PR0024732	P1	0.60	10	Rio Bairoa
Aguas Buenas WTP	PR0022896	PR1	0.081	1	Morena Creek
Las Carolinas WWTP	PR0024731	Ceased Discharge (8/2005)	0.22	20	Rio Caguitas
Limit Type			Daily Max	Daily Max	

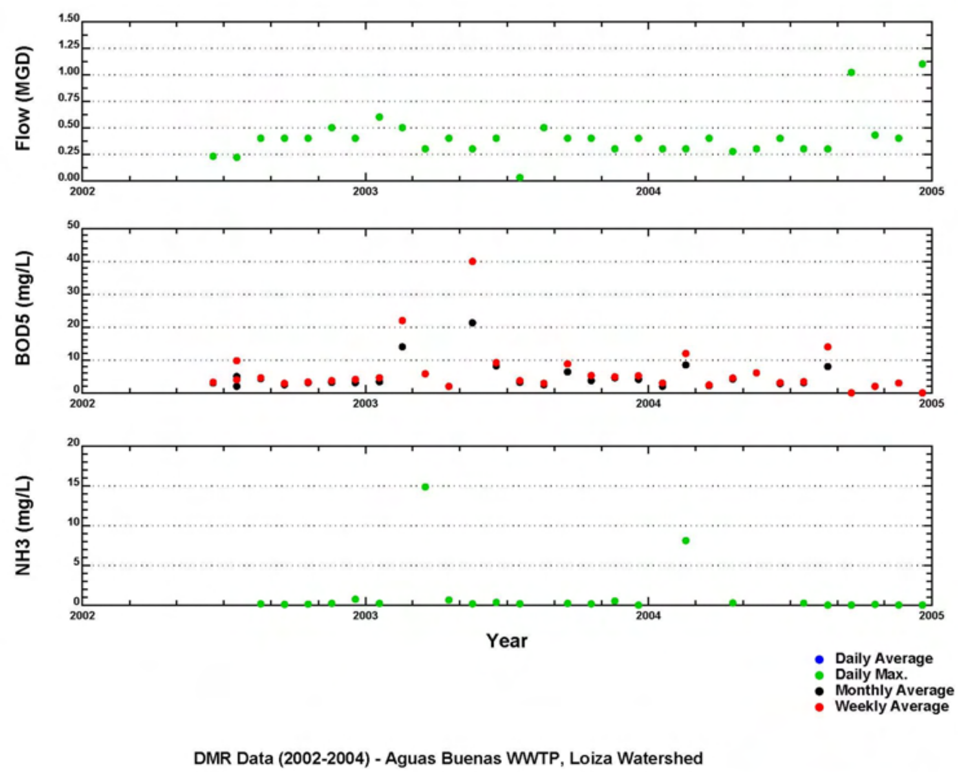
The available WWTP effluent data (flow and NH_3) for the Las Carolinas, and Aguas Buenas during 2002 to 2005 are presented in **Figures VIII-1 and 2**. The Las Carolinas WWTP ceased discharging in August 2005 and the wastewater is currently pumped to the Caguas WWTP. Typically, the Aguas Buenas WWTPs reports a good quality effluent with average effluent flow and NH_3 levels presented in Table VIII-2 (excludes upsets). The effluent data for Aguas Buenas WWTP show an occasional upset with the NH_3 levels greater 10 mg/l in early 2003 and another upset in early 2004 with the NH_3 level remaining below the permit limit.

Figure VIII-1



DMR Data (2002-2004) - Las Carolinas WWTP, Loiza Watershed

Figure VIII-2



The 2004 water treatment plant effluent data (flow and NH_3) for the Aguas Buenas WTP is also summarized in Table VIII-2. Typically, the Aguas Buenas WTP discharge is well below the permitted limit. The total ammonia load from this facility is less than 0.2 lbs/day.

Table VIII-2
AVERAGE EFFLUENT CHARACTERISTICS

Facility Name	NPDES #	Flow (mgd)	NH_3 (mg/l)	NH_3 (lbs/day)
Las Carolinas WWTP	PR0020273	0.32	11	29.4
Aguas Buenas WWTP	PR0024732	0.36	0.3	0.9
Aguas Buenas WTP	PR0022896	0.04	0.56	0.18

The pump station bypass load of NH_3 is estimated to be 1% of the WWTP flow and the WWTP permit limit ([lbs/day] = 0.01 x flow [mgd] x 8.34 x concentration [mg/L]). Because pump station bypass is illegal and will be address through NPDES compliance enforcement, the TMDL load for pump station bypass of NH_3 equals 0.0 ug/L.

2.2 Assessment of Nonpoint and Storm Water Point Sources

Nonpoint and storm water point sources include dry weather as well as storm-driven loads from various land uses. Nonpoint sources include animal feeding operations and grazing, septic system failures, urban runoff and for this analysis wastewater pumping station failures and sewer system overflows.

As discussed in Section IV, The Rio Grande de Loiza watershed was delineated into 15 subwatersheds (see Figure IV-1). The two streams being analyzed here are located within LPSC Segments 5 (Rio Bairoa) and 7 (Rio Caguitas). It should be noted that the area of each subwatershed area is greater than the drainage area of the listed assessment unit. The LSPC subwatersheds were only utilized to identify potential sources within the drainage areas that could have an impact on water quality.

Animal Feeding Operations/Grazing

Every AFO was inspected to determine its location (GPS), as well as its operational characteristics. The animal feeding operations located in the LSPC segments are summarized in Table VIII-3 and are identified in Table B-3.

Table VIII-3
ANIMAL FEEDING OPERATIONS

LSPC Segment	Stream	Dairy	Horse	Poultry	Swine	Beef
5	Rio Bairoa	0	0	0	0	0
7	Rio Caguitas	0	2	1	0	0

Septic Tank Failures

As a first step, visits were made to PRASA regional offices, as well as municipal offices. Based upon these interviews, discussions with University of Puerto Rico/Agricultural Extension Service personnel, as well as field visits to typical areas to observe field conditions, the unsewered population was determined.

Table VIII-4
SEWERED/UNSEWERED POPULATION

LSPC Segment	Total Population	Sewered Population	Unsewered Population	% Unsewered
5	13,793	11,591	2,202	16
7	67,662	44,516	23,146	34

Urban Runoff

Municipalities in Puerto Rico have not currently implemented the permitted storm water pollution control program.. Therefore, all urban runoff is considered a nonpoint source.

3.0 WATER QUALITY ANALYSIS

As described in EPA Guidance, a TMDL identifies the loading capacity of a water body for a particular pollutant. EPA regulations define the loading capacity as the greatest amount of loading that a water body can receive without violating water quality standards (40 CFR 130.2).

The loadings are required to be expressed as either mass-per-time, toxicity or other appropriate measures (40 CFR 130.2(i)). For a total ammonia TMDL, it is appropriate to express the TMDL on a daily basis. Daily pollutant loadings are more critical to river dissolved oxygen during low flow conditions, especially during the 7Q2 critical stream flow.

3.1 Surface Water Quality Data Overview

The United States Geological Service (USGS) maintains Water Quality Stations 50055400 (Station 3 on Figure IV-1, Rio Bairoa near Caguas) and 50055250 (Station 2 on Figure IV-1, Rio Caguitas at HWY 30 at Caguas). Chronological plots of USGS data for total nitrogen and dissolved inorganic nitrogen from 1994 to 2004 for these two stations are presented in Figures A-20 and 21, respectively. Also, PREQB data from 2001 to 2005 taken at the USGS stations are presented in Figures A-26 and A-27. The ammonia standard of 1.0 mg/l is represented by the dashed line. Review of the USGS and PREQB data presented in these figures show the ammonia standard to be substantially violated on the Rio Caguitas. However, on the Rio Bairoa, data show the ammonia standard periodically being violated through 2003 and being met in 2004.

3.2 Water Quality Load Calculation

The pollutant, ammonia (for toxicity), is considered to be a conservative pollutant where instream impacts are associated at the point of discharge. To determine the allowable loadings to these streams, a simple dilution mass balance calculation at the point of discharge is suitable to determine the waste load allocation necessary to meet the water quality standard. The following equation represents the mass balance approach used:

$$Q_u c_u + Q_e c_e = (Q_u + Q_e) c_d$$

where: Q_u = upstream flow (cfs);
c_u = upstream concentration (mg/L);
Q_e = effluent flow (cfs);
C_e = effluent concentration (mg/L); and
C_d = downstream (mixed) concentration (mg/L).

This equation was solved for c_e to determine the allowable effluent concentration and loading (WLA) given the upstream flow at 7Q2 and background concentration level, effluent design flow and water quality standard (c_d). The NPS LA was determined based on the upstream flow and concentration or, if more than one point source (PS) on a stream reach, as the upstream load plus the incremental load based on the incremental flow between the two locations. If there was a downstream PS, the load from the upstream PS was accounted for in the analysis.

The 7Q2 critical stream flows were determined using the USEPA DFLOW3 stream flow analysis program (http://epa.gov/waterscience/dflow/) and available USGS flow data. The USGS flow data used to calculate 7Q2 low flows were from Rio Bairoa (#50055390, 1990-2000), Rio Caguitas (#50055225, 1990-2003), Rio Gurabo (50057000, 1959-2003) and Rio Grande de Loiza (#50055000, 1959-2003). The DFLOW3 program is a Windows based implementation of the USEPA methodology for stream design flow determination for steady-state modeling as presented in Book VI of the technical guidance manual for performing wasteload allocations (USEPA, 1986). To determine 7Q2 flows at locations other than the flow gages, a drainage area ratio approach was used. For the Rio Bairoa and the Rio Caguitas, the 7Q2 is 2.6 cfs and 6.0 cfs respectively. Analysis of available water quality data in Rio Bairoa (USGS gage #50055400) and Rio Caguitas (USGS gage #50055250) determined the background ammonia concentration to be 0.2 mg/l based on approximate minimum observed concentrations.

For the Rio Caguitas and Rio Bairoa, the total ammonia standard of 1 mg/l is upstream of the USGS gage 50055250 (Caguitas) and gage 50055400 (Bairoa). As a result of the Las Carolinas WWTP ceasing discharge to the Rio Caguitas, the total ammonia standard will be met. The background ammonia concentration is approximately 0.2 mg/l at 7Q2 low flow conditions with a Waste Load Allocation now equal to zero (0) and the Load Allocation for Rio Caguitas is 6.4 lbs/day. For the Rio Bairoa, using an upstream 7Q2 low-flow of 2.6 cfs, a background ammonia concentration of 0.2 mg/l and the Aguas Buenos WWTP flow of 0.6 mgd, the mass balance analysis downstream of the outfall results in a Waste Load Allocation for the Aguas Buenas WWTP of 7.5 lbs/day. The Rio Bairoa LA is 2.8 lbs/day for a TMDL load of 10.3 lbs/day.

4.0 MARGIN OF SAFETY

A Margin of Safety (MOS) is provided to account for lack of knowledge concerning the relationship between load and waste load allocations and water quality (CWA Section 303(d)(1)(C), 40 CFR 130.7(c). The MOS, as described in USEPA guidance (EPA's 1991 TMDL Guidance and Sutfin (2002)), explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis), or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading for the margin of safety must be identified.

This TMDL contains an explicit MOS of 10%.

5.0 SEASONAL VARIATIONS/CRITICAL CONDITIONS

Weather patterns are tropical in nature with seasonal variation in the frequency of intermittent heavy rainfall events. However, drought events do occur periodically. While there may be some variability on a year-to-year basis due to weather pattern variability, these TMDLs are based on the 7Q2 critical stream flow for each of the impacted stream segment and, hence, are protective for all seasons. The 7Q2 critical stream flow is the minimum 7-day average stream flow that occurs once in two years and represents a critical low-flow stream condition used in performing WLAs. In addition, the instream water quality due to the PS loads at flows greater than the 7Q2 will result in compliance with water quality standards due to the increased dilution flow and, therefore, water quality will be protected at higher stream flows.

6.0 PHASE I TMDL ALLOCATION

The Water Quality load calculation approach determined the allowable loads (PS and NPS) that are required to meet the ammonia standard of 1.0 mg/l were based on critical low-flow conditions (7Q2). This analysis identifies a potential WWTP effluent permit limit for Aguas Buenas, but a more rigorous analysis should be completed before modifying any permit limits.

Table VIII-5
AMMONIA TMDL LOADS

Water Body	WLA (lb/d)	LA (lb/d)	MOS (lb/d)	TMDL (lb/d)
Rio Caguitas	0	5.76	0.64	6.4
Rio Bairoa	7.5	1.77	1.03	10.3

Table VIII-6 summarizes the loads and WWTP effluent discharge conditions.

Table VIII-6
TMDL AND LIMITS*

Facility Name	Flow (mgd)	Effluent Concentration Maximum (Permit Limit) (mg/L)	Current Load Maximum (Permit limit) (lbs/day)	Individual WLAs NH_3 (lbs/day)
Las Carolinas WWTP	0.22	19.43	0	0
Las Carolinas Pump Station	0.0022	0.1943	0	0
Aguas Buenas WWTP	0.60	N/A	N/A	6.82
Aguas Buenas Pump Station	0.0080	N/A	N/A	0
Aguas Buenas WTP	0.081	1.87	1.27	0.68

*The WLAs are individual WLAs summed under the Rio Bairoa in Table VIII-5

The achievement of the TMDL is addressed in Section 8.

7.0 REASONABLE ASSURANCE

Reasonable assurance for the implementation of this TMDL has been considered for the dissolved oxygen point and nonpoint sources for which management recommendations have been made within this report. The implementation will require the support of a variety of governmental, as well as non-governmental entities.

The complex nature of the implementation needs have been recognized throughout development of the Phase I program and have been accommodated through the regular involvement of government agencies in Technical and Executive Steering Committees (USEPA, PREQB, PRDOH, PRASA), as well as the involvement of other agencies at appropriate times (USDA, PRDNR, UPR). A Stakeholder Involvement Program has also been initiated to include municipal government, industry groups, public organizations, including environmental groups and local citizenry, and commerce.

It is the expectation that these efforts will produce the governmental as well as public and industry support necessary to accomplish the implementation of the activities which have been specified as required to fulfill the Phase I TMDL. It is anticipated that this support will need to include information, education effort, financial and other incentives, and regulatory follow-up.

8.0 IMPLEMENTATION

A review of all point and nonpoint sources of ammonia to these segments has resulted in the identification of the following options for reducing ammonia inputs.

8.1 Wastewater Treatment Plant Conditions/Operation

To meet the total ammonia standard in Rio Bairoa, the Aguas Buenos WWTP permit limit for ammonia concentration needs to be reduced from its current 10 mg/l (based on DO considerations) to 1.5 mg/l (based on un-ionized ammonia toxicity considerations). The TMDL analysis identifies this potential permit limit for Aguas Buenas WWTP, but a more rigorous analysis should be completed before modifying any permit limits.

As discussed in Section 2.1 above, the Aguas Buenas WWTP has produced a good quality effluent over the period 2002 to 2005. The average ammonia concentration, excluding upsets, is 0.3 mg/l, well below the current permit limit of 10 mg/l and below the 1.5 mg/l needed to achieve the TMDL.

8.2 Pasture (Animal Feeding Operation/Grazing Controls)

Although visits to AFOs throughout the watershed found them to be, for the most part, in compliance with the requirements of the Environmental Quality Board (EQB), it was noted that guidance does not exist for grazing animals (horses and cows) and that recommended manure management practices for all animals may allow input of biochemical oxygen demanding substances into the streams.

Recommended AFO/Grazing controls would include: exclusion of grazing livestock from the vicinity of streams through location of alternate water sources, as well as placement of feed; stream bank improvements to minimize or eliminate erosion through bank stabilization and limited fencing; filtered and improved manure management practices to ensure proper placement and stabilization.

Studies* have shown implementation of these recommendations could reduce the nitrogen load from these sources by 60%.

8.3 Septic Tank Management

It is estimated that the existing failure rate of septic tanks within the watershed is approximately 50% (estimates by many exceed this number, but a conservative estimate is used). These failures are the result of lack of maintenance, as well as placement in areas which do not support their use (high groundwater, thin soils, impervious soils, inappropriate grades, etc.). These failures result in overflows onto ground surfaces which may flow directly to streams or may be present on soil surfaces and carried by runoff during wet weather events to those streams. A goal of reducing the failure rate to less than 5% is considered reasonable. Through septic tank management including more stringent controls on placement (new construction), more stringent control of maintenance practices, efforts to identify areas where septic tanks exist but cannot function adequately due to geologic conditions, and provision of alternate sewage disposal options (holding tanks, extension of PRASA sewerage, community WWTPs), this goal can be achieved.

In the immediate future, septic system owners should be educated on the proper use and maintenance of a septic system.

* USEPA, Polluted Runoff, Management Measures Guidance

8.4 Sewage Pumping Station Bypass and Collection System Overflow Elimination

An asset management program aimed such as EPA's Voluntary Capacity Management Operation and Maintenance (CMOM) program at eliminating the loadings from sewage pumping stations and collection system is needed to achieve water quality standards.

8.5 Municipal Storm Water Management

The municipalities should implement the Best Management Practices (BMP) as proposed in EPA's Draft General Permit to further reduce the nonpoint source load.

9.0 FOLLOW-UP MONITORING

A phased approach to implementation is appropriate for the ammonia TMDLs, considering the highly variable nature of nonpoint source pollutant loads. This approach requires that monitoring be conducted to the response of instream water quality as load reductions are made over time. Water quality monitoring has been conducted by the PREQB and the USGS at the water quality monitoring stations identified above on a quarterly basis. These efforts will continue to track water quality improvements and to assure that the ammonia water quality standard is achieved. A detailed monitoring program is incorporated within the Phase II program recommendations section of this report.

10.0 STAKEHOLDER INVOLVEMENT/PUBLIC PARTICIPATION

A Stakeholder Involvement Program aimed at involving all elements of the public (municipal government, industry, commerce, public, organizations, general, public, etc.) within the watershed has been ongoing. The goal is to assure the participation of all those that will be affected in the development of the goals and objectives, as well as the implementation of the recommendations of the study. A further goal is the establishment of a structure and membership which will serve the ongoing need for a watershed steward group, assuring a continued focus on improving water quality through the implementation of the recommendations of this study, as well as of those which may be developed in the future.

IX. PHASE 2 PROGRAM

1.0 INTRODUCTION

Twenty-three (23) Phase 1 TMDLs have been produced for 13 assessment units. Each TMDL provides a total maximum daily load for each water body assigned to all point sources (WLAs) and non-point sources (LAs) which have been identified. Implementation plans supporting the accomplishment of these assigned loads are included as well.

Throughout the Phase 1 program extending from May 2005 through June 2006, effort was focused on the development of these TMDLs and water quality management and implementation plans utilizing existing and readily available data. While limited field investigation was performed to verify essential information, the goal was to produce Phase 1 products which were matched to the existing state of knowledge and to identify a Phase 2 program which would build upon Phase 1, fill in essential data gaps, monitor water quality response to Phase 1 management program implementation, and ultimately complete the water quality management plan and implementation strategies for the two major watersheds. The following scope of work, drawing from the recommendations which have been included in Milestone Reports 1 through 5 provides a 3-year study plan to accomplish this. It is broken down by the key Phase 2 tasks, includes a time frame of reporting and meetings and assumes that the existing intergovernmental committee structure will continue from Phase 1 through Phase 2.

There has been discussion throughout the Phase 1 program concerning sediment loadings and management strategies for reduction which might be appropriately included in both the Phase 1 and Phase 2 watershed efforts. In accordance with these discussions, while TMDLs for sediment are beyond the scope of proposed Phase 2 efforts, information will be developed within the area, specific tasks outlined in the following sections, which will be utilized in the development of load reduction strategies for sediment which will be part of the Phase 2 program.

2.0 PHASE 2 TASKS

<u>Task GT - Ground Truthing</u>

- Field monitoring and inspection program to verify Phase 1 assumptions. Program to be implemented in limited areas of select watersheds.

- Fecal bacteria are principal Parameter of Interest (POI).

- Subwatershed selection criteria includes:

  - Manageable size
  - Lack of interfering load sources
  - Ease of monitoring
  - Water quality priority

- Loading Sources of Interest

  - Septic systems/household wastewater disposal
  - AFOs/grazing

- Modify assumptions based upon findings and produce revised TMDL documents as appropriate including implementation plan and strategy for all covered assessment units.

Task MPI - Management Plan Implementation

- Develop area specific implementation strategies (can be same areas as selected in task GT but not mandatory) for control of phosphorous and fecal bacteria.

- Utilize expanded stakeholder involvement.

- Identify and receive resources to accomplish.

- Implement septic system/household wastewater disposal options in limited areas.

- Implement AFO/grazing and forest load reduction options in limited areas.

- Monitor and assess water quality response.

- Modify assumptions based upon findings and produce revised TMDL documents as appropriate including implementation plan and strategy for all covered assessment units.

Task TBLL - TMDLs Below Lake Loiza

- Expand geographic scope of work to include TMDL support documents for all assessment units within the Rio Grande de Loiza watershed located below the Carraizo Dam (near shore coastal monitoring/modeling is not contemplated).

- Preliminary list of new assessment units (AUs):

  - Rio Grande de Loiza (PRER 104b-00)
  - Rio Canovanas (PRER 0101b-02 & 0101a-01)
  - Rio Canovanillas (PRER 0103-00)
  - Quebrada Maracuto (PRER 0104a-01, 02, 03, 04)
  - Quebrada Bocaforma (PREC 0102-00)
  - Caño Zequiera (PREK 0097-00)
  - Caño Gallardo (PREK 0096-00)
  - Caño Norberto (PREK 0099-00)
  - Caño Machicote (PREK 0098-00)
  - Caño Carrasco (PREK 0100-00)

- Likely parameters of interest (303[d]):

  - Fecal coliform (enterococcus at marine boundaries)
  - Arsenic
  - Cyanide

- Additional municipalities:

  - Carolina
  - Canavanas
  - Trujillo Alto
  - Loiza

- Additional point source discharges:
  - Water treatment plants
    * Canovanas
    * Cubuy
  - Non municipal
    * Crown cork
    * S.U. Cubuy Ward School
  - Municipal storm water
    * Carolina
    * Canovanas
    * Trujillo Alto
    * Loiza
  - PRASA wastewater pumping stations
    * Approximately 20
- Additional animal feeding operations/grazing:
  - Approximately 50

<u>Task MSST - Miscellaneous Substance Source Trackdown</u>

- The miscellaneous substances for which source trackdowns will be performed are copper, selenium, cyanide and arsenic.

- Limited ambient sampling will be performed in assessment units where water quality violations have been noted.

- Potential sources will be identified where ambient sampling confirms presence.

- Limited soil sampling may be performed.
- Conclusions as to significance of water quality problems, as well as sources of problems and TMDL support documents as appropriate.

Task RPP - Review PRASA Permits

- Review PRASA permits and supporting information to understand how effluent $CBOD_5$ and NH_3 limits were developed (WLA calculations). Review facility operational data to determine compliance status and opportunities for administrative correction. This review will be completed to determine whether there is the ability to modify the $CBOD_5$ and NH_3 effluent limits to benefit the wastewater treatment plant compliance with NPDES permit limits while still maintaining compliance with the DO standard at the 7Q2 low flow.

Task IDO - Instream Dissolved Oxygen

- In the Rio Grande de Loiza watershed, there are four rivers/streams that do not meet the DO standard (based on monitoring data) and/or are on the 303(d) list of impaired waters for DO. These water bodies are Rio Gurabo, Rio Caguitas, the Rio Bairoa and the upstream Rio Grande de Loiza. Some of these water bodies receive wastewater treatment plant discharges but others do not. The cause of the low DO levels is not clear. Another complicating factor is pump station failures that can contribute high oxygen demanding material ($CBOD_5$ and NH_3) that may also contribute to low DO levels. In order to better understand the DO dynamics in these water bodies, a monitoring program will be conducted in conjunction with water quality model development to allow for development of TMDLs.

Task SIP - Stakeholder Involvement Program

- The Phase 1 stakeholder involvement program will be continued and expanded to garner the support and involvement of the various watershed stakeholders in the various implementation strategies, as well as the general support and interest in water quality improvement. Included will be meetings, events, educational tools and other awareness building, as well as partnership opportunities.